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Sky and TELESCOPE

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THE TEACHERS' COMMITTEE of the American Astronomical Society has investigated the procedures involved in obtaining government surplus materials for educational purposes. There are, and will continue to be for some time, opportunities to obtain at reduced prices telescopes, binoculars, cameras, photographic supplies, navigation equipment of all sorts, projectors, training films, and many other items that can be used with profit in the teaching of astronomy and navigation.

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On March 25, 1946, there was a change in the manner of distributing much of this equipment. All materials will now be handled strictly through regional offices, listed on page 15, the Washington offices of the RFC and the WAA controlling the standardization of prices but not the handling of such materials. The regional offices are furnished with lists of materials as soon as they are declared available surplus. Your institution may have its own agent authorized to contact these regional offices and in such a case your request should be made by this agent. Otherwise, you should contact the regional office yourself, preferably in person, and make your needs known.

In any case, be as specific as possible in describing your needs. For instance, requests for "a camera" or "a telescope" are apt to be overlooked and more definite requests, such as for "a telescope of three inches aperture" or a "35-mm. f/2.5 camera, shutter speeds up to 1/400 second," will be given preference. The turnover is rapid and you must be ready to close a transaction quickly.

It is obviously impossible for the Teachers' Committee to act as a clearing-house or jobber for astronomy laboratories over the country. The responsibility for obtaining such equipment must rest with your institution and yourself.

J. ALLEN HYNEK
Chairman, Teachers' Comm., A.A.S.

(*The War Assets Administration offices are listed on page 15.*)

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MAY, 1946

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BACK COVER: A southern portion of the moon near first quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. The reproduction is reduced 10 to 7 from a 7.8 enlargement of the original negative. (See In Focus.)

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What Becomes of the Novae?

By Dean B. McLaughlin, *Observatory of the University of Michigan*

IT WAS two a.m. and cloudy. There seemed to be little point in waiting longer; there was nothing that could not be observed just as well the next night or the next. And that last table of wave lengths in the spectrum of Nova Herculis would be more reliable if the final checking were done when I was less drowsy.

The phone rang in the observatory office and I went down to answer, muttering to myself, "Some inebriate wants to know whether the sun will rise tomorrow." A feminine voice asked, "Will you accept a collect telegram from Cambridge, Massachusetts?" I've had that same feeling just before totality at a solar eclipse. To myself I said, "This is it!" and aloud, "Yes, go ahead."

The clouds broke 20 minutes later; and as the bright dawn was erasing the last 2nd-magnitude star I closed the plateholder slide and ended the fifth exposure on the spectrum of Nova Lacertae 1936.

The outburst of a nova is an occasion for telegrams, minor headlines, major headaches, hurried preparation of charts and establishment of magnitude sequences, and general excitement on the part of all who are interested in observing it. The decline into obscurity carries no such excitement. At first you observe it every good night, but after it is down four magnitudes or so you can skip a night or two with a clear conscience. Then you observe it once a week. Still later you put it off; it will be there next week. At last there comes a "next week" when it is beyond the reach of your instrument.

The unknown and unexpected guest had burst upon you very unceremoniously and, like "the man who came to dinner," had taken pretty complete charge of your life and kept you in a constant state of turmoil with his changing moods. And now he has quietly slipped away and you miss the petty tyrant.

For many years, the place to which all good novae go was a legendary never-never land. Occasional glimpses of it were had from afar, but its detailed exploration has been accomplished only relatively recently. And the only way to be sure of reaching it is to follow the trail of a nova.

A good deal of misinformation has been current at various times concerning the fate of novae. Most of this has resulted from too free speculation, jumping at conclusions, and failure to notice established, even if obscure, facts. For instance, it has been suggested that practically the whole star is dissipated in the explosion, so that what remains is a mere fragment, though the observed equality of brightness of the pre-nova and post-nova star in several cases should have suggested the error of such a view. When Nova Herculis appeared to be double, some conjectured that the actual fission of a star had been witnessed, ignoring the fact that the original star was simply engulfed in the intense light of two nebulous knots that were rushing from it. The most persistent of these notions is the supposition that every planetary nebula is the "wreck of an ancient nova" — a picturesque speculation, not without romantic appeal, but it is based only upon a superficial resemblance of the planetaries to the nebulae that expand around novae.

If we are to gain the clearest understanding of what happens, we must observe a nova with reasonable frequency all the way down its decline. This has been done adequately in only one case, Nova Aquilae 1918, but it is now being done for Nova Herculis 1934, which is still fading. Unfortunately, T Coronae Borealis (which recently made nova news) has an unresolved companion, a class *M* giant red star, which considerably outshines the minimum light of the nova and whose spectrum submerges that of the latter. As I write, the continuous spectrum of the red star dominates in the red and yellow region of the spectrum, though bright lines of the nova's spectrum stand out above it. In the blue and violet, the nova spectrum is still reasonably uncontaminated. (See the spectra of T Coronae Borealis in *Sky and Telescope* for April.)

There are fragmentary observations of several novae in the later stages of decline. For our knowledge of the spectra of novae some years after they have returned to minimum, we are chiefly indebted to Milton Humason, of Mount Wilson Observatory, who has observed a considerable number of them. The detailed record of Nova Aquilae correlates the observations of all the others, and the resulting picture is a consistent one.

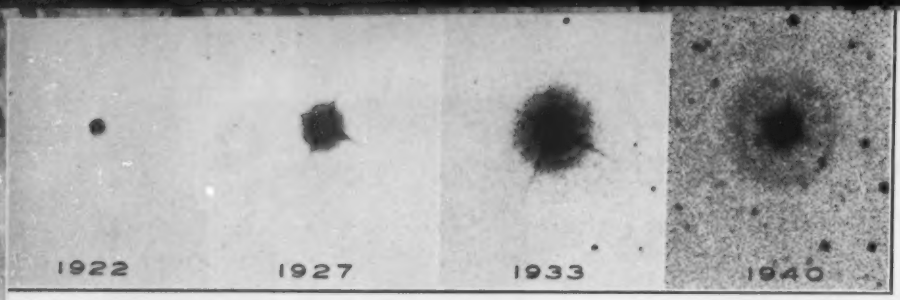
When a nova has just passed maximum, its spectrum shows a characteristic pattern of broad bright bands with dark lines on their violetward edges. (See Fig. 1.) We have learned to interpret this structure in terms of the Doppler effect in a cloud of gases that is being erupted from the star in all directions. The various speeds of approach and recession of the gases, relative to the observer, shift the bright (emission) lines by different amounts to the violet and red, respectively, and this results in the broad bright band. But the nearest gases, approaching the observer, absorb light from the bright cloud behind them, and this makes the dark (absorption) lines strongly shifted toward the violet.

The cloud thins out as it rushes farther from the star, and the dark lines fade, but the wide bright bands remain to advertise the continuing expansion. With a knowledge of the speed (obtained from the Doppler shift) and the time interval since maximum light, we can calculate the size of the cloud. For example, the shell of gas around Nova Aquilae expanded at the rate of about 1,000 miles per second. In one month its radius must have been 2½ billion miles, nearly as large as the orbit of Neptune. No wonder that by that time its spectrum had changed so that it closely resembled that of a gaseous nebula, for it *was* a nebula so far as density was concerned. (Fig. 1.)

In spite of its enormous dimensions, this cloud of gas around Nova Aquilae a month after the explosion still appeared as a point of light, like any other star, in the largest telescopes. But a few months later, Barnard discovered a tiny disk or nebula surrounding the star. Its diameter grew steadily, at the rate of two seconds of arc per year. In the upper portion of Fig. 2 are shown four stages in this history.

The identity of this little nebulous disk with the cloud that produced the wide bands in the earlier stages was proven by spectra taken with the slit

Fig. 1. The spectrum of Nova Herculis, photographed at the University of Michigan Observatory. Above: In January, 1935, shortly after maximum light, showing broad bright bands with absorption in their violetward edges. Below: In the nebular stage, 10 months after the outburst.



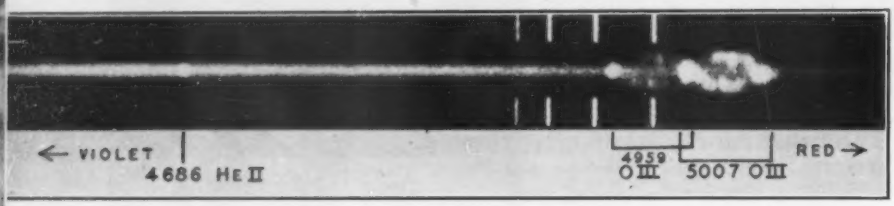
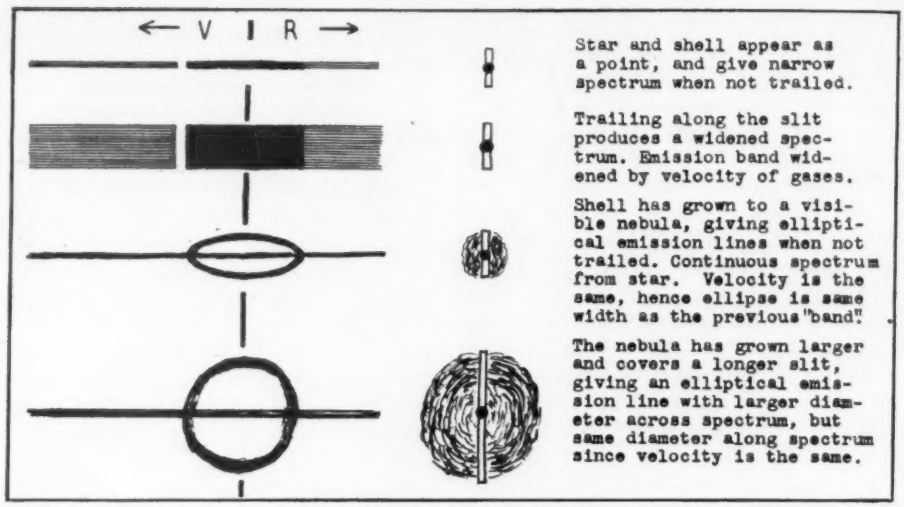


Fig. 2 (at left). Top: The expanding nebula around Nova Aquilae 1918, taken at Mount Wilson. These are negatives. The central strong spot is the much-overexposed image of the star; the four rays are due to light diffraction by the secondary mirror supports.

Below: The spectrum of Nova Aquilae and its expanding nebula shell, photographed with iron comparison lines at Mount Wilson in July, 1920, with a much greater scale than in the direct photographs above. The horizontal streak is the star's spectrum, continuous except for the bright knot 4686 of ionized helium. At the right are two Doppler ellipses of doubly ionized oxygen, formed as explained in Fig. 3.

Fig. 3 (below). The formation of elliptical patterns of nebular lines from expanding nova shells.


← V I R →
Star and shell appear as a point, and give narrow spectrum when not trailed.
Trailing along the slit produces a widened spectrum. Emission band widened by velocity of gases.
Shell has grown to a visible nebula, giving elliptical emission lines when not trailed. Continuous spectrum from star. Velocity is the same, hence ellipse is same width as the previous "band".
The nebula has grown larger and covers a longer slit, giving an elliptical emission line with larger diameter across spectrum, but same diameter along spectrum since velocity is the same.

set along a diameter of the nebula and the star image held fixed at the center of the slit (instead of being allowed to trail the length of the slit). Then the bright nebular lines, instead of giving just broad bands of light, showed an elliptical form. (See Fig. 3.) The center of the nebula, near the star image, is partly between us and the star and partly beyond the star. The portion between us and the star is rushing toward us, and gives a line displaced violetward. The portion beyond the star is receding from us, and its line is shifted redward. Thus, the center of the disk gives double lines. But out at the apparent edges of the nebula, the motion is all *across* the line of sight, so that there is no Doppler shift. Now the width of the ellipse *across* the spectrum was just the diameter of the nebula; the width *along* the spectrum was the same as that of the bright bands seen in the spectrum long before the nebula had grown to visible dimensions, showing the Doppler effect and, hence, the speed of expansion, to be the same in both the early cloud and the later disk. Fig. 2, lower, shows the elliptical pattern of the nebular lines from the shell around Nova Aquilae 1918.

The spectrum of the star itself was continuous and without absorption lines. But at the place of the ionized helium line 4686, there was a little bright knot that belonged definitely to the star — not to the nebula. This knot remained in the star's spectrum through the years that followed, while the nebular shell kept on expanding at the same rate and faded away, so that no trace of the nebular lines could be seen in the spectrum. The star remains so to this day.

Nova Persei 1901 must have had a very similar history. It was not followed closely through its later decline, but after the star had reached minimum its expanding nebula likewise showed the elliptical pattern in the bright lines. But instead of a fairly uniform shell, this nova seems to have erupted a large mass of matter on one side, a smaller amount in a spherical cloud away from us, and very little directly toward us. The result is the peculiar fishhook form of the lines in Fig. 4, which represent about half of a spherical shell, instead of a complete one as in Nova Aquilae.

Dr. Baade has recently photographed other old novae with special red-sensitive plates and has found previously undetected nebular shells about them. The apparent dimensions of these nebulae, combined with the expansion velocities, make possible a fairly accurate calculation of the distances of the novae. Thus it is found, for example, that Nova Aquilae 1918 is 1,400 light-years from the solar system.

Nova Herculis has a nebula that illustrates another of the vagaries of the matter ejected from novae. Looking at the center and right-hand portions of Fig. 5, one would find it hard to believe that they are photographs of the same object. The center picture was taken in the light of doubly ionized oxygen; the right, in light radiated by ionized nitrogen. This latter radiation is very weak in the region of the outer ends of the major axis of the ellipse shown by oxygen, and oxygen is slightly weaker where the nitrogen emission is strongest, though this is not evident in the reproduction. The "double star" seen by G. P. Kuiper, of Yerkes Observatory, in the early stages of expansion of the nebula, was due to two nebulous knots in the upper right and lower left portions of the nebula, as is shown in Fig. 5.

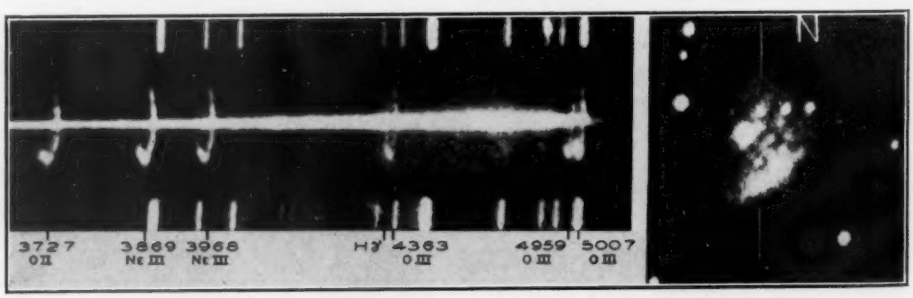


Fig. 4. At left, the spectrum of Nova Persei (1901) and its nebular shell in 1934, photographed with helium comparison lines by Humason at Mount Wilson. The horizontal bright strip is the continuous spectrum of the star. Each bright "fishhook" is about half a Doppler ellipse in the light of one of the lines emitted by the nebula. At right, the nebula around Nova Persei in 1934, also by Humason. The fine line represents the position of the spectrograph slit when the spectrum was taken.

The shell about Nova Aquilae has practically faded away and that around Nova Persei is becoming much fainter. The Nova Herculis nebula will probably not become a difficult object for several years. None of these nebulae showed any noticeable slackening of their rates of growth, and it is easy to calculate that the star's gravitational attraction can never slow down the shell appreciably after it has become so large. If the well-known planetary nebulae were the results of nova explosions, then they too should reveal similar rapid rates of expansion. A few do show very slow expansion — a few tens of miles per second — but most of them have pretty sharp lines. So, alas for romantic speculation, they are not old novae of the typical violent kind. If they result from any kind of nova activity at all, it must be from such ultra-slow novae as RT Serpentis, in which the maximum of light lasted some 15 years and the velocity of ejection was extremely slow.

To this categorical denial of nova origin of the planetary nebulae there is one known exception. The Crab nebula does show high velocities of expansion, and it occupies the position in Taurus in which Chinese astronomers recorded a brilliant nova in 1054. It was undoubtedly a supernova. We cannot tell the story here, but refer the reader to John C. Duncan's article in *Sky and Telescope,* October, 1942.

Now that the nebular shells of our novae have cleared away, let us look at the stars that remain. Nova Persei is now varying between the 12th and 14th (visual) magnitudes in a quite irregular manner. If we had known it only since its outburst in 1901, we might say it has not yet quieted down. But Harvard photographs that preceded the explosion show the star was variable before 1901, and with about the same range. Apparently its violent experience has not changed its habits. Nova Aquilae varied through a small range for 30 years before its great explosion, and now that the show is over it is actually quieter than before.

Owing to its recent second full-scale outburst, the behavior of T Coronae Borealis at minimum is of the greatest interest. For many years after it had faded to minimum following its outburst in 1866, it varied only slightly, if at all. There were some definite temporary flarings early in the present century, but it was not until about 10 years ago that it showed conspicuous activity. Between May, 1936, and August, 1938, it increased from the 11th to the 10th photographic magnitude. The true increase was certainly much greater, for when the star appears of the 11th magnitude, most of the observed light is that of the giant red companion. For several years it remained bright with some fluctuations. Suddenly, in 1945, it faded to minimum again. With the brightening in 1936-38, the *M*-type spectrum of the red giant was swamped by the continuous spectrum of a very hot star, strong in the blue and violet, and with strong bright lines of hydrogen and ionized helium. When the fading occurred in 1945, the nova-like spectrum practically disappeared, leaving the red giant dominant. And then look at what happened!

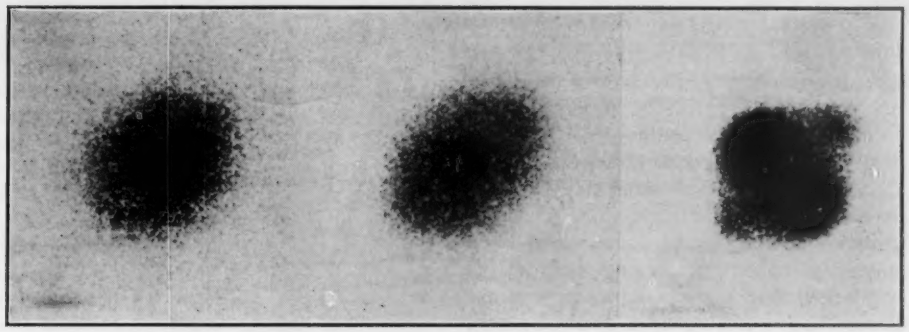


Fig. 5. Nova Herculis and its nebular shell, photographed by Baade at Mount Wilson in 1942. Left: The star and nebula in blue light. Center: In the light of the "nebular" green lines of doubly ionized oxygen, isolated by a filter, which suppresses the star. Right: The nebula in the light of ionized nitrogen, showing the radical difference of distribution of the radiating atoms of this element.

About half of the old novae are more or less variable, and the rest are nearly or quite constant in their light. Our knowledge of their light variations is due in large measure to the persistence of the British amateur, W. H. Steavenson, who has followed several of them very closely for a number of years. Nova Persei furnishes the most conspicuous example of continuing variation near minimum (see the light curve in Fig. 6). Marked variations are shown also by Nova Ophiuchi 1848 and Nova Cygni 1876. But whether variable or constant, the old novae all seem much alike when their spectra are studied. Humason finds that all of them have continuous spectra very strong in the blue and violet, which indicates they are very hot stars. Some of them have nothing else, no absorption or emission lines. Others have bright lines of hydrogen and ionized helium. From their luminosities, which are similar to that of the sun on the average, we are forced to conclude that they are small super-dense stars, somewhat like white dwarfs, but not so extreme. They are a definite class of star, quite different from the members of the main sequence, to which the sun belongs.

The variable old novae are more interesting than the constant ones. If we had merely discovered any one of these in later years, without knowing of its nova outburst, we would call it an irregular variable. And if we had observed the spectral changes of the old nova T Coronae during 1936 to 1945, but without knowledge of its earlier history, we would have had no hesitation about calling it a nova-like variable and classifying it with Z Andromedae, which it closely resembled spectroscopically. The light curve of this variable is shown in Fig. 7. It had bright maxima in 1901, 1915, and 1939, and in the latter two cases these maxima were reached by a relatively rapid increase from minimum and were followed by large oscillations of light.

A dozen or more nova-like variables are known. Their variations of light are irregular, and their spectra simulate the changes of a typical nova spectrum in a way that shows they must be doing, in a relatively gentle manner, what a nova does with explosive violence. The word "relatively" is used advisedly. Here on earth we would call an explosion violent if it produced velocities of one mile per second. In the realm of the novae we have to adjust our scale so that even 50 miles per second indicates just a "gentle" oozing away of the stellar atmosphere!

How many of the nova-like variable

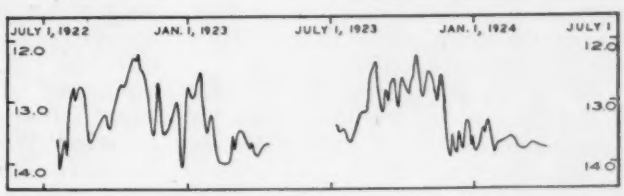
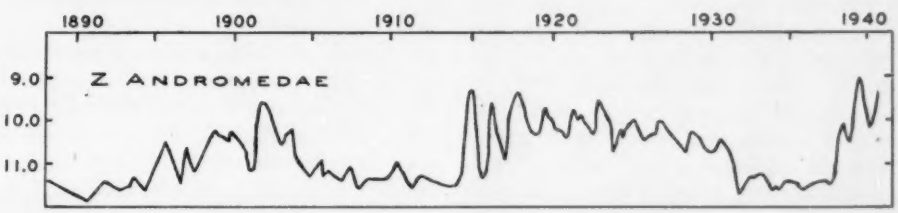


Fig. 6 (at right). Light curve of Nova Persei 1901 at "minimum," by Steavenson and Peek.

Fig. 7 (below). Light curve of Z Andromedae, from Harvard photos.



stars are really ancient novae? At least one of them appears fairly certain. The long-period variable star R Aquarii, a red pulsating giant, has a very hot companion star usually much fainter than R Aquarii at minimum. But several years ago, the companion brightened up and stole the show from its red mate. It has since subsided, but for a while, R Aquarii was pretty well swamped by a nova-like spectrum. Long before this happened, astronomers knew of a peculiarly shaped nebula around R Aquarii. Recent measures by Baade show that the nebula is expanding at a rate that indicates it left the star some six centuries ago. Thus, circumstantial evidence seems to point to R Aquarii's companion as an old nova.

It is curious that several other nova-like variables, as well as the two recurrent novae, T Coronae Borealis and RS Ophiuchi, have red giant stars for companions. Z Andromedae is a good example of this type of association. The more we know about novae and nova-like stars, the more difficult it is to draw a line between them. Just what is the difference between T Coronae and Z Andromedae, except that we have *recorded* true nova outbursts of the one and not of the other? Any and all of the so-called nova-like stars will bear watching. A full-scale nova outburst of Z Andromedae, AX Persei, or CI Cygni would not surprise me. And let us not forget the companion of Mira, a star whose spectrum is distinctly nova-like, and whose light varies!

The recurrent nova, T Pyxidis, had observed outbursts in 1890, 1902, 1920, and 1944 (Fig. 8). At its maximum in 1920, its spectrum was indistinguishable from that of a typical nova with only one recorded explosion; in its decline early in 1945 it showed no great difference from a typical nova at a similar stage. At its minimum between the outbursts, its spectrum was identical in appearance with any of several typical old novae. In no observable characteristic does it seem to differ from such a great nova as Nova Aquilae 1918, except in having a smaller range of magnitude than the typical nova and in the fact that we have *seen* it repeat. And what, after all, are the SS Cygni stars, with their outbursts of three or four magnitudes every couple of months, if not just miniature repeating novae?

In the face of the tendency to repeat, it is difficult to find any justification for believing in theories of accidental cause of novae, such as collision with either a star or a nebula. The cause must reside in the stars themselves. Since the post-nova stars are dense bodies, it has been suggested that collapse from low to high density accompanies the nova outburst. This would liberate enough energy to produce a supernova, and possibly supernovae do originate in such a way. For a common nova, a very slight adjustment would suffice to produce all the energy involved in the outburst; the post-nova star would have almost exactly the same density and diameter as the pre-nova star, and the luminosity before and after the outburst would not differ by a measurable amount. This is what we observe. The total mass of the star is almost negligibly altered by the ejection of a shell of gas. Cecilia Payne-Gaposchkin and S. Gaposchkin, of Harvard Observatory, have calculated that the ejected masses are only about 1/10,000 of the sun's mass.

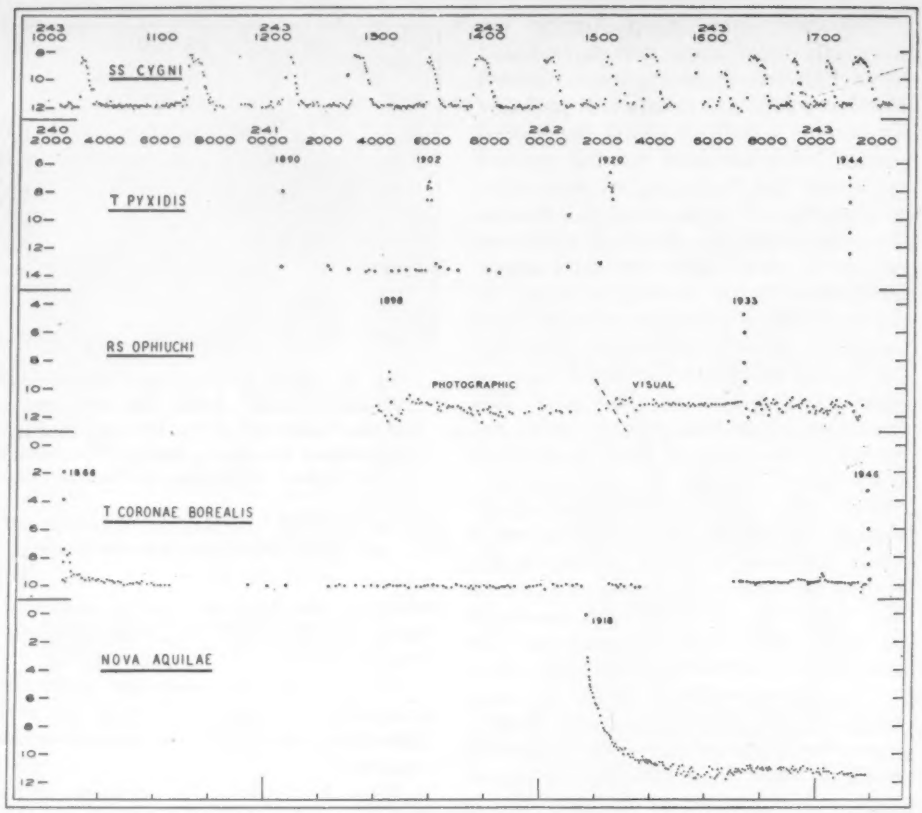


Fig. 8. Visual light curves of an irregular variable star, three known recurrent novae, and the great Nova Aquilae 1918, from the A.A.V.S.O. files. Note that the time-scale (in Julian days) for SS Cygni differs from those below.

Some years ago it was argued that, since novae occur at the rate of a score or so per year, in a few billion years every star would have been a nova. The fallacy here is obvious; what right have we to assume that a star can be a nova only once? As long as no recurrent novae were known, this supposition was possible, but it is now contradicted by observation. Certainly, T Pyxidis, RS Ophiuchi, and T Coronae Borealis, both before and after certain of their observed outbursts, were very similar in all essential respects to the old novae that have not yet been observed to repeat. From this we can infer that probably (there are still no definitive observations to prove this) the *great* novae before their explosions also were sensibly as we find them afterwards. Certainly their luminosities are similar before and after, and to explain this in any other way than by similar physical conditions would strain the laws of radiation.

Though we have located the cause within the stars, we do not know what it is. We can dismiss as grim humor the definition of a nova as a planet whose physicists have learned how to make super-atomic bombs, and there seems to be little chance that atomic fission is responsible. Under stellar conditions, it is hardly conceivable that a concentration of the critical mass of fissionable material could occur. Chemical purity was an essential in the success of the atomic bomb, and, save by actual design, it seems impossible that the right combination of the active substance and the moderator could be brought about. It is especially difficult to see how it could recur at intervals of only a few decades.

The answer to the question posed in the title of this article is that the novae become what they were originally, and it is distinctly possible that in the course of many centuries all novae repeat. "Once a nova, always a nova" is perhaps overstating the case, but a nova is a distinctive class of star long before and long after its great explosion. The novae of the future may include the old novae, the nova-like stars, and some supposed white dwarfs, as well as many faint catalogued stars whose spectra are as yet unknown.

If I believed in reincarnation, I would want it to happen to me so that I could observe Nova Persei at its next outburst. The observers in 1901 missed some things, and I would like a chance at them.

NEWS NOTES

By Dorrit Hoffleit

TYCHO'S STAR

Tycho's nova, the star B Cassiopeiae, invisible at more than 22 magnitudes fainter than when it shone as bright as Venus in 1572, is as laden with interest now as it was then. Its light curve has been classified as Type I by Dr. W. Baade, of Mount Wilson Observatory. Two other supernovae of this type have appeared in our own Milky Way system in the past 900 years. Their positions are found from the still visible expanding nebulosities caused by the stellar explosions of 1054 (the Crab nebula) and 1604. Dr. Baade states that B Cass "is of particular interest because it throws new light on the final state of a supernova." No star which could have been the supernova has been found on Mount Wilson plates showing stars to the 19th magnitude.

"If the shell is unobservable today," Dr. Baade writes in the *Astrophysical Journal,* "the reason must be that the excitation provided by the stellar remnant is insufficient." In the case of the Crab nebula, the central exciting star has all the earmarks of a white dwarf except that its bolometric absolute magnitude is —1 instead of +10. According to Chandrasekhar's theory, the end product of a supernova is a white dwarf; but the fully developed white dwarf stage (degenerate matter throughout the star) is achieved only after some finite time. The implication is that B Cass, having an absolute bolometric magnitude probably fainter than 5, is much closer to the final white dwarf stage than the other two stars. Although the remnant of the star is too faint for discovery with the 60-inch, and its declination is too high for the 100-inch telescope, Dr. Baade says, "there is every prospect that it will be found when the 200-inch comes into operation."

ECLIPSE RESULTS

Reports on studies of the total solar eclipse of July, 1945, are already abundant. *Popular Astronomisk Tidskrift* devotes more than 40 pages to the work of Swedish and Finnish astronomers. *Popular Astronomy* has had several accounts, especially by the "Princeton party," who obtained color photographs of the corona, motion picture films showing the inner corona during the whole of totality, and the motion of the moon's shadow across broken clouds.

Dr. Harlan T. Stetson in the *Scientific Monthly* calls attention to results by J. T. Wilson in the *Electrical Review.* Measurements of the atmospheric potential gradient were made before, during, and after the eclipse. The sun is responsible for the state of ionization and excitation of our atmosphere. What happens when the source of the stimulating radiation is abruptly cut off? "While before totality the potential gradient of the atmosphere registered steadily about 150 volts negative, within three minutes after the duration of the total phase the gradient dropped rapidly to zero, reversed in sign and actually attained about 75 volts positive; after which it again returned to the apparently normal pre-eclipse value." The delay in the fall of the atmospheric potential was three minutes, while fully 40 minutes elapsed after totality before the regain of normal potential. These observations add stimulus to future eclipse expeditions, especially for the study of effects at times of greater sunspot activity.

MEDAL TO ASTRONOMERS

Among 1946 recipients of the Potts medal of the Franklin Institute are Dr. Bengt Edlen, of the University of Lund, Sweden, and Dr. Ira S. Bowen, director of the Mount Wilson Observatory. Dr. Edlen is honored for his studies of the solar corona, and Dr. Bowen for his analysis of the spectra of nebulae. The medals were awarded on April 17th, at the annual medal day exercises of the Franklin Institute in Philadelphia.

DANGER!

The ambition of modern rocket ships is to ascend beyond the earth's upper atmosphere. But — if a meteor should strike the ship! Dr. Joseph Kaplan, of the University of California at Los Angeles, points out through Science Service the fatality of a collision. Even the slowest meteors strike the earth's atmosphere at 30,000 miles an hour, the faster ones at 180,000. About 75 million enter the atmosphere daily, but nearly all are vaporized by friction before they have a chance to reach the ground. But the space ship will not enjoy the blanketing protection of the atmosphere. Fortunately, says Dr. Kaplan, the meteoritic particles are rather far apart, the most concentrated swarms averaging about 1/30 of an ounce of material in 20 cubic miles of space.

A LEAP-YEAR RULE

The *Monthly Notices* of the Astronomical Society of South Africa point out a fact perhaps not generally known. When Greece and Rumania adopted the Gregorian calendar in 1924, they modified its leap-year rule. Every fourth year except a century year is leap year, but if the century year divided by 900 gives a remainder of 2 or 6, it too is a leap year. In this way the length of the tropical year averages 365.242222 days, whereas the true length is 365.242199, or a difference of only two seconds! This amounts to one day in 43,000 years, whereas in the conventional Gregorian system the vernal equinox occurs one day off in only 3,300 years. The two systems will agree exactly until the year 2800, which is a leap year in the usual system only.

BOMB-TEST OBSERVATIONS

Cameras without lenses will be used for some of the photographic observations planned by the Army and Navy, in co-operation with Eastman Kodak Company scientists, for the Bikini tests of the atomic bomb. To these cameras, the initial explosion may appear 1,000 times brighter than the sun, but application of the same technique as is used to measure the flash and energy of an ordinary photographic flash lamp is expected to give results.

In the lensless cameras, a film will move at high speed behind a slot over which step wedges of varying density and various filters will be attached. Some portions of the film may be burned out, but where the wedges are of extremely high density good results on the peak of the flash should be obtained. These cameras will take spectra as well as measure the intensity of the light from the bomb.

More than 24 Eastman high-speed motion picture cameras, running at 3,000 frames a second, will record the explosion from ships, planes, and radio-operated planes. Ten spectroscopic cameras and scores of aerial and general-purpose cameras equipped with special filters and lead cases to protect them from the terrific heat and radiation will be used, according to a recent Science Service release.

NEW DIRECTOR AT NAVAL OBSERVATORY

Announcement has been made of the appointment of Captain R. S. Wentworth as superintendent of the U.S. Naval Observatory in Washington, D.C., relieving Commodore J. F. Hellweg, who has served in this capacity for the past 16 years.

Captain Wentworth, 55 years old, was born and grew up in Brockton, Mass., and graduated from the U.S. Naval Academy in 1912. He has served in many ships and many waters. In particular, during World War I he was on the USS *Delaware,* which was a part of the British Grand Fleet; during the recent war he was Chief of Staff to the Commander, U. S. Naval Forces in Europe, from June, 1941, to August, 1942, and was commandant of the U. S. Naval Base in Iceland from May, 1943, to August, 1944.

American Astronomers Report

Here are highlights of some papers presented at the 74th meeting of the American Astronomical Society. Complete abstracts will appear in the Astronomical Journal.

Two Great Southern Galaxies

GALAXIES NGC 55 and NGC 253, in the constellation of Sculptor, were among the objects photographed by Dr. John C. Duncan, of Wellesley College, with the 100-inch telescope at Mount Wilson in the summer of 1945. NGC 55, in galactic latitude —77°, measures 29 by 3 minutes of arc. Although it has been classified as a spiral, Dr. Duncan's picture shows it as an irregular galaxy.

Two degrees from the south galactic pole is NGC 253, which has been assigned magnitude 7.0 by Shapley and Miss Ames, indicating that it is the second brightest spiral in the sky. It is the beautiful spiral, measuring 24 by 5 minutes of arc, pictured on this month's front cover. On the new photographs, obscuration is conspicuous, especially on the north-preceding side. Numerous bright stars are so arranged as evidently to belong to the galaxy, and there are several almost starlike objects that have a nebulous appearance.

Dr. Duncan reported that a comparison of the plate of September 2, 1945, with a negative of the same region taken by the Bruce telescope at Harvard's southern station at Bloemfontein, South Africa, was made by Dr. Harlow Shapley. The 100-inch plate, which had 50 minutes' exposure, shows stars to approximate magnitude 19.5 on the Harvard scale; the brightest stars which may be confidently considered part of the galaxy are of magnitude 17.5. The corresponding distance modulus (difference between absolute and apparent magnitude) is 23.8 magnitudes, giving a distance of the galaxy of 1,875,000 light-years, a diameter of about 13,000 light-years, and an absolute magnitude for its combined light of —16.8.

Red Giant Distribution

AT A DISTANCE of approximately 800 parsecs toward the galactic center, the ratio of the frequency of red giants to white (*A*) stars appears to be about three times as large as the same ratio among stars at about the same distance toward the anticenter. This conclusion was presented by Drs. Emma T. R. Williams and A. N. Vyssotsky, on the basis of spectral statistics in 87 sample regions lying between 11° and 20° north and south galactic latitudes, obtained at the McCormick Observatory of the University of Virginia.

Dr. Vyssotsky stated that this greater concentration of red giants toward the galactic center may be more than an effect of the local cloud of stars, and that it may actually represent the distribution of red giants in a less flattened ellipsoid (centered on the Milky Way center) than the ellipsoid which contains the *A* stars. He points to the observations by W. Baade, of Mount Wilson Observatory, which showed that the red giants in the Andromeda galaxy, M31, are highly concentrated in the central spheroid of that system whereas the blue and white stars are characteristic of the spiral arms.

Spectrum of Sun's Corona

MOST of the light of the inner corona of the sun is in its continuous spectrum, only a few per cent appearing as the well-known bright emission lines. The origin of the light forming the continuous coronal spectrum was discussed by Dr. Donald H. Menzel, of Harvard College Observatory. He suggested that there may be evidence which does not support the common explanation that the continuum is caused by scattering of sunlight by fast-moving free electrons.

Spectra of the corona may be made with the usual form of spectrograph equipped with a slit, or, since the observations are made during a total solar eclipse when the narrow circle of inner coronal light forms its own "slit," a slitless spectrograph may be used. Dr. Menzel prefers the latter arrangement, and points out that with a slit instrument scattered skylight could give a faint dark-line spectrum which might erroneously be attributed to the corona itself. On the other hand, with a slitless spectrograph, this danger does not exist, as skylight records only as a faint diffuse background fog.

Slitless spectra have the further advantage of revealing the distribution of light of various wave lengths all around the solar limb. Dr. Menzel called attention to the close correspondence between the coronal continuum and the green emission line at wave length 5303 angstroms. This line is produced by iron ionized 13 times (Fe XIV). Spectra taken at the eclipses of 1936 and 1932 show this correspondence. In 1932, particularly, when the red coronal emission at wave length 6374 was generally more intense than 5303 all around the sun's limb, except for two tiny condensations, the coronal continuum was confined primarily to these two regions. (See also front cover, *Sky and Telescope*, September, 1945.)

The line at 6374 angstroms is caused by iron ionized nine times (Fe X), and one might consider the lack of a continuum associated with this line as the result of the capture of the free electrons. But Dr. Menzel does not believe this to be an acceptable explanation, for he points out that even if the corona were made of pure iron, the change of ionization from Fe XIV to Fe X would reduce the number of free electrons present by only 30 per cent. Therefore, some continuum ought to be found associated with the line at 6374 as well as with that at 5303.

Dr. Menzel stated that these facts point to the need for further work (at eclipses) on the spectrum of the corona, particularly on the spectral and geometrical distribution of the continuum. Meanwhile, we should hesitate to accept the conventional explanation of electron scattering as the source of the continuum.

UX Monocerotis

THIRTY-TWO spectrograms obtained at the McDonald Observatory and 1,374 patrol plates taken at Harvard Observatory have been used by Dr. Sergei Gaposchkin, of the latter institution, to study this interesting eclipsing double star. The component stars, of classes *A*7p and *G*2p, are so nearly equal in brightness that both spectra are visible. The components are somewhat more massive than the sun, with the *G*2 star about three times as large in diameter as the other.

The spectral characteristics of this system are rather extraordinary, and the spectrum undergoes drastic changes from cycle to cycle. Dr. Gaposchkin suggests tentatively that the bluer component (the *A* star) has apparently a rotation about 15 times as fast as would be the case if it rotated with the revolution period of the two stars. At the same time, the blue component seems to eject a continuous stream of material from its far side, which spirals around the whole system, forming a tenuous envelope. This feature is similar to that of the famous eclipsing star Beta Lyrae.

Infrared Photography

WITHIN the past year the sensitivity of the I-Z plate has been increased approximately five times (with very careful hypersensitization), according to W. F. Swann, of the Eastman Kodak Company. He reported that with this infrared-sensitive film Mount Wilson Observatory has succeeded in obtaining spectra of some of the brighter stars beyond 11,000 angstroms.

Astronomers have benefited considerably by wartime improvements in emul-

sions for papers, plates, and films, and some of the changes have been incorporated in the spectroscopic plates used so extensively by astronomers all over the world. The most noteworthy of these changes have been in the infrared, in plates with high sensitivity, and in plates with extremely high resolving power. Mr. Swann said that the recently announced Type 649-GH spectroscopic plate is capable of resolving more than 1,000 lines per millimeter. Although it is of very little value for straight photography because of its low sensitivity, it is an extremely useful plate for making reticules and graticules.

More on Stellar Atmospheres

THAT the atmospheres of many stars have stratification of certain elements similar to that found in the sun was indicated by several papers. Spectroscopic analysis of the weaker lines in the spectra of Arcturus and 70 Ophiuchi A has been made by Suzanne E. A. van Dijke, National Research fellow at Mount Wilson Observatory. Arcturus is a giant orange star, while 70 Ophiuchi A is a dwarf of the same type. Stratification of the elements in the atmosphere of Arcturus was suggested as a result of this study.

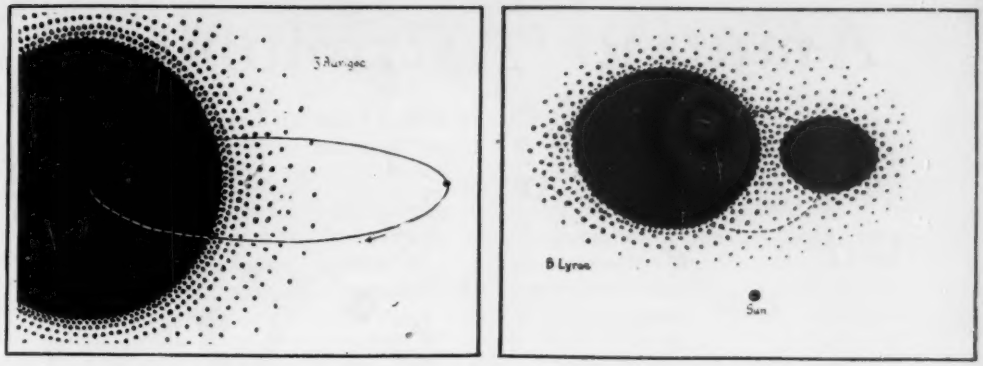
At Dominion Astrophysical Observatory, Victoria, B.C., Dr. K. O. Wright has measured the intensities of 1,000 lines in the spectrum of Alpha Persei, and computed curves of growth, which relate the intensity of a line to the number of atoms which produce it. He finds that the neutral atoms of an element show a somewhat higher excitation temperature than do its ionized atoms, that the neutral atoms appear subject to greater pressure, and that the turbulent velocity is less for them than for their ionized counterparts. All these results suggest, tentatively, that there is appreciable stratification in the atmosphere of Alpha Persei, with the mean position of the ionized atoms lying above that of the neutral atoms.

NOTICE

EFFECTIVE with new subscriptions ordered after June 1st, and with renewals ordered after July 1st, the price of Sky and Telescope is increased to $3.00 per year for the United States and possessions; to $3.50 for Canada and countries in the Pan-American Postal Union; and to $4.00 for all other foreign countries. On June 1st, the single copy price by mail becomes 30 cents; over-the-counter, 25 cents.

Current subscriptions expiring with the issue of June, 1946, and thereafter, will be billed at the new rates, but may be renewed at present rates until July 1st. All current subscriptions may be extended for any period at present rates before that date.

SKY PUBLISHING CORPORATION



Schematic diagrams of two famous eclipsing binaries, Zeta Aurigae and Beta Lyrae. The period of Zeta Aurigae is 972 days; that of Beta Lyrae is 12.9 days. In the former the stars are relatively far apart; in the latter they are close together and suffer considerable tidal distortion.

Prominence on Zeta Aurigae?

THE DOUBLE STAR Zeta Aurigae can be regarded as a prototype of a rapidly growing class of eclipsing systems in which a late-type supergiant is attended by an early-type main sequence star. In this case, the components are of spectral ciasses *K*5 and late *B*, with the *K*-type supergiant roughly 70 times as large as its mate, the uncertainty of this figure being five to 10 per cent. The disparity in these sizes is thus such that the radius of the *B* star is comparable with the extent of the chromosphere surrounding the *K* star. Consequently, Dr. Zdenek Kopal, of Harvard College Observatory, has found the phenomena exhibited when the *B* star is eclipsed to furnish a unique opportunity for studying the structure of the *K* chromosphere in considerable detail.

Dr. Kopal has analyzed the light curve of the beginning of the eclipse of Zeta Aurigae which extended from December 18, 1939, to January 28, 1940 (eclipses occur three times in eight years), and found that the light changes at that time bore little resemblance to any theoretical light curve of a bodily eclipse. Dr. Kopal finds that at the beginning of the eclipse the *B* star must have been obscured first by an almost completely opaque cloud of width equal roughly to one half the radius of the *B* star, or about one million kilometers. The blue star then passed behind a somewhat wider and more transparent region before disappearing ultimately behind the limb of the *K* star; this limb, as far as can be determined, may have been quite sharp.

By assuming that the depth of the cloud in the *K* star's atmosphere was equal to its lateral width, and that its continuous absorption was due to metallic ions, Dr. Kopal found the density of the cloud to be of the same order of magnitude as that of solar prominences. This hypothetical cloud might be considered a gigantic prominence, but in comparison with the size of the supergiant star it need not have been any more conspicuous than an average-sized prominence on the sun.

If this interpretation of the 1939 eclipse light curve is correct, the passage of the *B* star behind a "prominence" of the *K* star was probably a rare chance which might not reoccur for several revolutions of this binary system. Whether or not this is so only future eclipses can decide, and Dr. Kopal suggests that rare and fleeting events such as eclipses of Zeta Aurigae should be observed with great care and accuracy.

Atmospheric Nitrous Oxide

AN APPARENTLY plausible and interesting means of accounting for the presence of nitrous oxide (N_2O) in air was reported by Dr. Arthur Adel, of the University of Michigan, who several years ago discovered an absorption band in the solar spectrum at wave length 7.77 mu. This he identified as being produced by nitrous oxide in the earth's atmosphere, even though the presence of this gas is not readily explained by the photochemistry of the air.

The explanation relayed by Dr. Adel to the American Astronomical Society was suggested by M. W. Kriegel, of the Carter Oil Company, Tulsa, Okla. In recent examinations of soil air for hydrocarbon content, Mr. Kriegel has found a hitherto unreported component which he believes to be nitrous oxide. Its presence in soil air may result from the decomposition of ammonium nitrate (NH_4NO_3) into water and nitrous oxide. It is also probable that the slow decomposition of commercial fertilizers may account for this gas in farming areas. Furthermore, in connection with the studies of decomposition of vegetation under aerobic conditions, it has been shown by the laboratory of the Carter Oil Company that a gas having properties similar to nitrous oxide forms a large portion of the condensed fraction.

Dr. Adel believes it is not unreasonable to suppose that escaping soil air is one source, if not the principal one, of the atmospheric nitrous oxide which produces the band at 7.77 mu.

Amateur Astronomers

Exhibit and Program Plans for Detroit Convention

ADEQUATE SPACE for a floor exhibit of amateur-made telescopes, more than enough illuminated display cases for scale models, eyepieces, accessories, mirrors, and miscellaneous items, and wall space for all photographs have been promised by Dr. Robert T. Hatt, director of the Cranbrook Institute of Science, where the main sessions of the Fourth National Convention of amateurs will be held on July 4th weekend.

Amateurs everywhere, whether personally attending the convention or not, are invited to send in exhibits to Cranbrook; the following are the official exhibit classifications:

1. Telescopes (amateur made).
2. Photographs of amateur-made instruments and observatories.
3. Small-scale models of existing or contemplated instruments.
4. Telescope parts and accessories, amateur made, including such items as eyepieces, mirrors, diagonals, finder scopes, spectroscopes, focusing devices.
5. Astronomical photographs taken with amateur telescopes.
6. Miscellaneous items.

Entry rules and cards are now being printed and will be sent to individuals and groups who request them from L. H. Sprinkle, Exhibits Chairman, 19323 Hillcrest Blvd., Farmington, Mich.

All amateur groups are invited, by request of Mabel Sterns, of the National Capital Astronomers, to send, in advance, copies of all literature employed in publicity work, together with information on the number of members employed in membership and publicity activities. This is to form the background for one of the group discussions. Address these to Publicity Discussion, Mrs. Margaret Back, at the address below.

Tentative program. Inasmuch as July 4th allows time for delegates to travel, events are scheduled to begin Friday morning and to end about noontime Sunday. Note the opportunity to visit two of America's finest observatories.

July 5. 9:00 a.m. Registration of delegates (fee $1.00). Morning program includes tour of Cranbrook and first convention session.

2:00 p.m. Tour of McMath-Hulbert Observatory, Lake Angelus, with explanation of techniques and showing of latest films of solar activity.

7:45 p.m. Showing of films of Paricutin volcano, taken and presented by Major Otto Fisher, who has recorded the eruption in sound and color since it began in 1944. Weather permitting, telescopes outdoors for observing into the night. Delegates traveling by car are invited to bring portable instruments.

July 6. Morning program devoted to activities of amateurs, reports of delegates, and discussion of publicity methods.

12:30 p.m. Official banquet, with invited speakers. Group photograph. Afternoon sessions will deal with amateur organization problems, reports of committees, problems of future activities.

Evening visit to University of Michigan Observatory at Ann Arbor, featuring observing with several large telescopes, and demonstration of spectrogram techniques.

July 7. Morning sessions devoted to exhibit awards, discussions of telescope makers' and observers' problems.

Travel. Delegates traveling by car are advised to spend the night of Thursday, July 4th, at cabins or tourist places outside the Detroit suburbs. Those arriving by bus or train Friday morning may take either a Pontiac or Birmingham bus at the Greyhound bus terminal in Detroit, making sure to get off at the Birmingham bus station, about an hour's ride from Detroit. Do not get off at Lone Pine Road, even though it is nearer Cranbrook, as there is no shelter there.

Members of the Detroit and Northwest societies will provide cars to meet delegates at the Birmingham bus station; these cars will ply back and forth to Cranbrook every 15 minutes from 8:30 to 10:30 Friday morning, July 5th. Anyone arriving after 10:30 should call the Cranbrook Institute of Science, Birmingham 377, and this is also the phone for

THIS MONTH'S MEETINGS

Boston: Dr. Arthur C. Hardy, of Massachusetts Institute of Technology, will speak on "A New Method of Rating the Power of Telescopes," at the meeting of the Amateur Telescope Makers of Boston, May 9th, 8:00 p.m., Harvard College Observatory, Cambridge.

Chicago: Dr. Walter Bartky, University of Chicago, will speak on "Stellar Motions in the Next Million Years," at the May 14th meeting of the Burnham Astronomical Society. Motion picture films will be shown. The society meets at the Chicago Academy of Sciences Auditorium, at 8:00 p.m.

Cincinnati: The Cincinnati Astronomical Association will hold its annual Star-Gaze on Saturday, May 11th, to which the public is especially invited. Telescopes will be available. Meet at the end of the Fairview car line, Route No. 60, at 8 o'clock.

Cleveland: "Navigation with Radar" will be discussed by Dr. J. S. Hall, of Amherst College, at the May 3rd meeting of the Cleveland Astronomical Society, 8 o'clock at the Warner and Swasey Observatory.

Detroit: Dr. Charles F. Meyer, of Wayne University, will address the Detroit Astronomical Society on May 12th at 3:00 p.m., at Wayne University. His subject is: "A Review of a New Theory of the Origin of the Solar System by Weizsaecker."

Geneva, Ill.: On Sunday, May 26th, at 4 o'clock, the Fox Valley Astronomical Society will hold an astronomical picnic at Aurora College. The lecture subject is to be announced, and there will be observing in the evening, weather permitting. Bring your own basket lunch, but coffee will be provided.

Indianapolis: Howard Miner will speak on "Teaching Astronomy" at the May meeting of the Indiana Astronomical Society, May 5th, 2:15 p.m. at Odeon Hall.

Madison, Wis.: On May 8th, Dr. C. M. Huffer, of Washburn Observatory, will speak on "Astronomical Pictures," at the meeting of the Madison Astronomical Society, 8:00 p.m. at Washburn Observatory.

New York: The annual meeting of the Amateur Astronomers Association will be held on May 15th at 8 o'clock in the Roosevelt Memorial building, American Museum of Natural History. There will be motion pictures, reports of officers and committees, elections, and entertainment.

Pittsburgh: Arthur L. Draper, director of the Buhl Planetarium, will give at the May 10th meeting of the Amateur Astronomers Association a special presentation of the "theater of the stars," featuring a behind-the-scenes demonstration of the planetarium instrument. The group meets at 8 o'clock in the Buhl Planetarium.

people needing directions or help of any kind. If necessary, taxis are available at the Birmingham bus station.

For the visits to Lake Angelus and Ann Arbor, members' cars and public conveyances will be provided for all who require them, so those who do not come by car need have no fear that they will lose out on these trips.

Room and meal reservations. Two hundred *single* rooms are available. They will be reserved only for the two-day period commencing after breakfast Friday, July 5th, and ending after breakfast on Sunday, July 7th. (Rooms must be vacated by 9:30 a.m. Sunday, although the convention sessions will continue to 12:30 p.m.) The cost, per person, for six meals and two nights is $10.00. Reservations should be made by June 10th, but the rooms may all be filled before that date. Adjoining rooms can be reserved for families. Only 100 blankets are available, so if you come by car, bring a blanket or two for each person. The Cranbrook blankets will be assigned to those coming by bus or train. If you wish only meals, and not room reservations, at Cranbrook during the convention, request such reservations by June 15th.

Send all room and meal reservations to the undersigned.

MARGARET BACK
Convention committee chairman
46 Edgemere Road
Grosse Pointe Farms 30, Mich.

Historic Telescope Exhibited

The *Bulletin* of the Eastbay Astronomical Association of Oakland, Cal., for February, contains the following report:

"What fun we had on Saturday evening, February 2nd, setting up the old Davidson 6.4-inch refractor! This is an historic telescope. As accurately as we can learn, it was made to exhibit at the Centennial Exposition in Philadelphia in 1876, with the mechanical parts by Fauth and Company of Washington and optical parts by Alvan S. Clark.

"Dr. Edison Pettit, of Mt. Wilson, had made a visit to Chabot and helped us in advance in identifying certain parts. We also found in the Chabot Observatory library a Fauth and Company catalog for 1878 containing a cut of the instrument and of the gold medal award to it in 1876. We began at scratch and got most of the parts in the right place, and after stepping on one another's toes for two hours and dropping many screws (for it seems to be built of screws), the telescope was set up in the Exhibit Room. It creates much interest. As far as we know, the first observatory in California contained this telescope set up by Dr. George Davidson in Lafayette Park in San Francisco in 1878. It is not yet certain when it was dismantled, but it was in use in the park for over 20 years."

Report from Copenhagen

A MEETING of the executive committee and delegates of the International Astronomical Union was held in the Academy of Sciences and Letters, Copenhagen, Denmark, from March 7th to 13th. Although this was not by any means a full-scale meeting of the I. A. U., it was especially important as the first session of any kind since 1938, and many important decisions were reached, including tentative plans for the next general meeting of the I. A. U. This will probably be held in Europe, but not before 1948. The actual determination of the time and place of the next meeting is left to the executive committee.

Twenty-four astronomers from 14 countries comprised the delegates, and only representatives from Spain and Italy failed to arrive. The four members of the executive committee who attended were Spencer Jones, Danjon, Oort, and Stebbins (representing Adams). The members of the Danish national committee, Hertzsprung, Norlund, B. Stroemgren, and E. Stroemgren, also attended most of the meetings, and on the day a symposium on interstellar matter was held, a number of young astronomers and physicists came from Denmark and from Lund, Sweden. Most of the delegates traveled to the meeting by airplane, including the United States' group comprising Shapley, Stebbins, and Struve.

Five special committees were set up for the meeting. These were on solar phenomena, variable stars, fundamental astronomy and minor planets, bibliography, nominating.

The executive committee, at the close of the meeting, proposed changes in the form of the **Quarterly Bulletin** of Commission 11 of the I.A.U. These changes reflect the trend in solar investigations and the relation to problems of radio transmission. The bulletin is to remain a separate publication, as it is a summary giving results as early as possible, whereas other publications necessarily involve a delay before results appear. In the **Quarterly Bulletin,** the characteristic numbers should be dropped, except the sunspot number. Added to the daily record should be details of coronal phenomena, radio noises of solar origin, and the luminescence of the night sky. A better index of prominence activity than the present one should be established, and details of solar eruptions should continue to be published as at present.

Commission 11 will also be asked to study the question of the prediction of terrestrial phenomena of solar origin and the determination of zones of activity on the sun's disk. The importance of arranging a continuous cinematographic study of the sun from stations spaced around the world was stressed.

It was also recommended that the commission on variable stars assume the responsibility for the naming of variables. Commission 27 will also be asked to assume responsibility for the publication every five years of the **Catalogue and Ephemerides of Variable Stars,** with intervening annual supplements. As with all the other committees, the variable star group considered many problems related to the publication of various journals and catalogues summarizing fundamental results, the continued appearance of which was interrupted or completely stopped by the war.

In considering the problems of fundamental astronomy and minor planets, attention was drawn to a project initiated by the U. S. Naval Observatory whereby a number of photographic zenith tubes may be set up in different latitudes and longitudes for the purpose of obtaining better information on latitude variation as well as on the systematic errors of existing systems of proper motion. It was proposed that an information center for this project be formed at the Naval Observatory, Washington, D. C.

The problem of minor planets, a field in which German astronomers have always been very active, both in observing and in the compilation and publication of results, was carefully considered. It was proposed that the computation of ephemerides of known minor planets be shared by the Institute of Theoretical Astronomy at Leningrad and the Rechen-institut at Heidelberg; that the Students Observatory at Berkeley, Cal., be approached on the computation of orbits of newly discovered asteroids.

The astronomers of the 12 nations represented joined in advocating the creation of an international astronomical observatory and research station under the auspices of the United Nations. Dr. Shapley, author of this proposal, suggested that the United Nations Educational, Scientific and Cultural Organization (UNESCO) consider establishment of truly international institutes in special fields, such as public health, new foods, astronomy, and atomic energy. The scientists involved would be able to set the pattern for friendly, active international co-operation. The Polish delegation advocated both north and south international observatories.

It was significant that in the rearrangement of the work of the international astronomical bureaus which were suspended during the war, many former German activities were assigned to Russian astronomers and observatories. The Soviet delegation to Copenhagen reported plans for sending a group of leading Russian astronomers to America soon, preparatory to rebuilding observatories in Russia on as modern a basis as possible. Dr. A. Mikhailov was elected to the I.A.U. executive committee, its six other members now being from England, France, Holland, Italy, Sweden, and the United States.

The delegates present were: Delporte from Belgium; Link, Czechoslovakia; E. Stroemgren, Denmark; d'Azambuja, Danjon, Fayet, France; Greaves, Spencer Jones (chairman), Stratton, Great Britain; Minnaert, Oort, Netherlands; Randers, Norway; Banachiewicz, Witkowski, Poland; Gullon y Senespleda (absent), Spain; Lindblad, Sweden; Guyot, Switzerland; Shapley, Stebbins, Struve, United States; Mikhailov, G. Shajn, Mrs. G. Shajn, U.S.S.R.; Junkes, Vatican City State.

The region of the Northern Cross. The small circle encloses 61 Cygni, first star whose distance was measured.

SPRING AND SUMM

By Catharine E. Barry, *Hayden Planetarium*

A LOVE for the glory of the heavens is no modern craze. It has always been a fervor of the human soul. In the days of the prophets, when Job was extolling the powers of the Creator, nothing appealed to him more firmly than the fact that it was He "which maketh Arcturus, Orion and Pleiades, and the chambers of the south . . . ." And yet countless men and women, today, share the regret of Thomas Carlyle when he said, "Why did not somebody teach me the constellations, and make me at home in the starry heavens which are always overhead, and which I don't half know to this day?" We do not have to iterate that lament and let us say we shall not.

While any season at all is the right time to begin learning the constellations, spring has certain advantages. As warmer weather beckons us out of doors to survey awakening nature, there is a renewed invitation to notice the moving panorama exhibited in the evening skies. We feel ourselves to be Lilliputians in the presence of the legion of stars. And the more we learn from the hard facts of observation, the greater is the awe and the splendor of the stars.

The evening skies of spring for northern observers are less spectacular than those of winter — they do not claim as many brilliant stars. The whole scene has become more placid as befits the milder season. This is the best time, however, to study the circumpolar constellations, those which never set in mid-northern latitudes. They should be well fixed in the memory, as they can be seen on any clear night the year round.

Ursa Major, the Big Bear, in the early evening hours in April and May, stands high in the northern sky above the pole. At this time of year observers in the Southern Hemisphere may also see this constellation above their northern horizon; however, those south of about 28 degrees below the equator cannot see the entire Dipper.

This Big Dipper is an asterism within Ursa Major, and definitely looks like the object for which it is named. It has three stars in the handle and four in the bowl, all but one of about equal brilliance. The Dipper has other designations, such as the "Butcher's Cleaver," "Charles' Wain" (Wagon), and the "Plough." No matter when or where it is seen, an imaginary line joining the two stars forming the side of the bowl farthest from the handle, the pointer stars, if extended nearly six times its length will end near Polaris, the North Star. Polaris is of about the same brightness as the Pointers, and there are no bright stars between. Polaris cannot be seen, of course, by observers more than a degree or so south of the equator.

The star at the end of the handle of the Dipper is called Alkaid, or sometimes Benetnasch. The one next to it is Mizar. Close beside Mizar is a 4th-magnitude star called Alcor. This star is said to be a test for eyesight, although really it is not difficult to see at any time under good conditions. Mizar is interesting historically, as it was the first star to be discovered and mentioned as a double star; it was also the first double to be satisfactorily photographed. Its brighter component was the first star discovered with a spectroscope to be double. The third star in the handle of the Dipper is Alioth. Where the handle joins the bowl is Megrez, and below it is Phecda. The Pointers are called Merak and Dubhe, the latter being the closer to the pole. By summer, the Dipper will have slipped west of Polaris.

It is a very interesting fact that all the stars of the Big Dipper, except Alkaid and Dubhe, are moving together through space. A considerable number of other stars, widely scattered, have the same motion. One of these is Sirius in Canis Major; it is the nearest of the group. Beta Aurigae (the bright star east of Capella) is the most remote, at a distance of 135 light-years. These stars range from eight to 400 times as bright as the sun.

Ursa Major includes, besides the bright stars of the Dipper, many others of lesser brilliance. Not all of these stars, however, are circumpolar at latitude 40° north. When the constellation is observed just after dark in the spring, the group of stars to the west

I know that I am mortal and ephemeral; but when I scan the multitudinous circling spirals of the stars, no longer do I touch earth with my feet, but sit with Zeus himself, and take my fill of the ambrosial food of gods.

Quoted in Mackail's *Anthology*, iv.32.

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of the Pointers forms a crude semicircle, with a pair of stars near each other at its southern end. Starting with the stars at the bottom of the bowl of the Dipper, we find another group of stars arranged in almost the same manner and likewise ending with a pair of stars. A third pair is then observed in line with the first two. The fact that each of these pairs is nearly a duplicate of the other is a remarkable coincidence. The pairs have been likened to the tracks of a leaping gazelle; they represent the paws of the bear.

Polaris and the north celestial pole lie in the constellation of Ursa Minor, the Little Bear, also called the Little Dipper. Polaris is the bright star at the end of the handle. Farthest from the handle and corresponding to the Pointers in the Big Dipper are two bright stars known as the guardians of the pole; they circle about it closer than any other conspicuous stars, Polaris excepted. The Little Dipper is not so readily found as the Big Dipper, although Polaris and the guardians are easily seen. The other stars are unobtrusive and missed when there is a slight haze or moonlight.

Cepheus is one of the inconspicuous circumpolar constellations, situated at this season below and east of the pole; it is rather difficult to locate except in a dark sky. It lies in the Milky Way, as does also the much more conspicuous neighboring constellation of Cassiopeia. The bright stars of this latter group form an irregular W or M, according to its position.

A part of Camelopardalis, the Giraffe, is close to the pole. The brightest star is magnitude 4.3, for Camelopardalis was formed to fill in a large region between the ancient constellations. In order to identify its stars, study the star chart on page 22 until you have the configuration well in mind.

Draco, the Dragon, was known to the Greeks, the Egyptians, and the Arabs. To the Greeks it represented the serpent guarding the Garden of the Hesperides. The Egyptians worshipped Draco in connection with their goddess Isis. Many of their temples were built so that the beams of Thuban, in the

MER STARS

Planetarium

tail of the dragon, shone upon their altars. These were constructed about 3000 B. C., when Thuban was the pole star. (For a chart of Draco and more detailed discussion, see *Sky and Telescope,* July, 1945, page 12.)

Among the non-circumpolar constellations, Leo, the Lion, is particularly associated with the springtime. The rising of its bright Sickle in the east at dusk is one of the first signs that spring is in the air. By early May it shines high in the south when the stars first come out and follows the sun closely to its setting in the west before the summer season is far advanced. The pointer stars of the Big Dipper, which help to find the North Star, can direct us to Leo as well. Sight along the line of the Pointers, toward the south this time and a little farther than before, and there stands the king of beasts.

Six stars form the large Sickle representing the head of the Lion. The brightest is Regulus at the base of the handle. A beautiful blue star, it was one of the four "royal stars" which were supposed long ago to rule over the heavens. Antares, in the Scorpion of the summer sky, Fomalhaut, in the Southern Fish, and Aldebaran, in the V-shaped face of Taurus, are the others.

Eastward from the Sickle there is a right triangle of stars which also belongs to Leo. At the eastern point of this triangle you will find the second brightest star in the constellation, Denebola, which marks the tip of the Lion's tail.

A line from the triangle of Leo through the middle of the Sickle and prolonged as far again beyond leads westward to the famous Beehive. More often known as Praesepe, the Manger, it is the light of a cluster of hundreds of stars 3,000 million million miles away. This little hazy patch can be glimpsed in a clear, moonless sky in the dim region of Cancer, between the Lion and the Twins.

Certain stars stand out among their fellows. The Big Dipper is the most popular figure for us who live in the Northern Hemisphere. Orion, a winter constellation, is the brightest and grandest. The Pleiades are the friendliest. The Northern Cross is the most sublime, and the Scorpion is the most formidable of the constellations.

Scorpius appears directly in the south in the evening sky of early summer. Its body is formed by the upper stars of the large group; its tail slants toward the horizon, then curves to the left and upward, a fine cascade of stars ending in the wide pair that marks the Scorpion's sting. Less imaginative people may see there, instead of a deadly scorpion, only the figure of a kite with a long curved tail.

One star in Scorpius clearly outshines the others; it is Antares, the "rival of Mars," often mistaken for our brother planet. Antares is 250 light-years away, a red supergiant sun. If it were 10 times as far away, it would be barely visible to the naked eye on the clearest night. At 1/10 of its distance, it would be second in splendor only to the planet Venus. This is true because Antares is so nearly a standard 1st-magnitude star.

Eastward from Antares across the wide stream of the Milky Way there is an inverted dipper figure of six stars, somewhat smaller than the Little Dipper near the pole of the heavens. It is called the Milk Dipper and is in the zodiacal constellation of Sagittarius, the Archer, which is pictured as a centaur aiming an arrow at the Scorpion. Some people imagine that the bright stars of the Archer outline the figure of a teapot — handle, spout, and all.

The region between Antares and the Milk Dipper is in many ways the most remarkable in all the heavens, whether viewed with the unaided eye, through binoculars or through a telescope, or on photographs of long exposure. Here, in the direction of the massive center of our galaxy, are found fine examples of almost every kind of object the system contains. Here are stars of different colors, double stars, and both open and globular clusters. In this region is the grandest of all star clouds, and here are vast dust clouds hiding whatever lies beyond them.

In late summer evenings the Milky Way, a wide glowing arch of remarkable variety and beauty, spans the whole heaven from the northeast to the southwest, its apex nearly overhead in the region of the Northern Cross. The six stars forming this large figure are part of Cygnus, the Swan, which appears to be flying down the Milky Way. Bright Deneb, the "tail" of the Swan, embellishes the top of the Cross. A star of the 1st magnitude, it is somewhat less brilliant than Vega farther to the west, although Deneb is intrinsically 75 times as bright as Vega and 4,800 times as bright as our sun. Deneb is 15 times farther away than Vega. Albireo, at the foot of the Cross, shows clearly through a very small telescope as a pair of stars of exquisitely contrasting colors. One is a 3rd-magnitude star of rich topaz hue, and the other, of the 5th magnitude, is turquoise blue.

Topping the sky of summer is Vega, the brightest star in the constellation of Lyra. In middle northern latitudes it is surpassed only by Sirius, the Dog Star, which by summer has moved into the daytime sky. Vega is a beautiful blue-white object 63 times as bright as the sun and 27 light-years away.

We have mentioned less than half of the constellations that are visible during spring and summer. This is just a starter — you need not stop here. Moderately prosaic folk, you and I, can forget the everyday world as we survey the starlit scene, and can allow our imaginations full play. And when the artless sunlight next morning reveals the obvious inadequacies of the things around us, something of the magic still lingers.

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BOOKS AND THE SKY

ELECTRONS IN ACTION

James Stokley. Whittlesey House, New York, 1946. 320 pages. $3.00.

AN ASTRONOMER sees science in its largest aspects. So when an author like James Stokley, whose background was long specialized on stars and planets, turns to discussing electrons and neutrons and science in general, he writes with wide and deep perception.

In this book, Astronomer Stokley traces the development and performance of electron tubes, the use of electronics in industry, electronic sound recording, electronic computers, X-rays, the betatron, the electron microscope, and medical instruments such as the metal locator, the inductotherm or fever machine, and the electroencephalograph. And up-to-date chapters cover radar, loran, and the atomic bomb. Thus the book becomes a complete and delightful exposition of all the new marvels of science and the electronic arts.

But to present readers one of the most interesting chapters in the book relates to "Cosmic Electronics." Here, for example, is a passage that describes interestingly the mechanism of radio blackouts coincident with excessive solar activity.

"When a large spot crosses the center of the Sun's disk, as seen from Earth, these electrons are aimed toward us. Nearing our planet, they are affected by another magnetic field, that of the Earth itself, and they spiral inward. Passing through the rarefied gases of the upper atmosphere from about 375 down to 125 miles, the height of the F layer, they cause additional ionization of the gases' atoms. When the knocked-out electrons return to their places, visible light is given off and we have a display of the aurora borealis, the 'northern lights.'

"Curiously, Dr. [Harlan T.] Stetson [of Massachusetts Institute of Technology] has found the maximum of auroras comes not at the sunspot maximum, but about two years later. This he explains by the fact that as the cycle advances, spots occur nearer and nearer to the Sun's equator. The path in which the Earth moves around the Sun is very nearly in the same plane as the solar equator. Thus, spots that occur early in the cycle, large though they may be, are aimed either above or below the Earth, while the later ones are directed more nearly toward us.

"Here, again, the radio effect varies with the frequency of the waves. Speaking in his WGY talk of the damage to radio reception done by the September, 1941 aurora, Dr. Stetson explained that records made at his Needham, Mass., laboratory . . . 'show very definitely that the upper layer from which the short radio waves are transmitted is damaged more promptly than the lower layer. This lower layer, on the other hand, shows the worst effect about a day after the aurora or two days after the sunspots are in line with the Earth. In the case of the shorter waves, recovery occurs within two or three days but more than a week elapses before the broadcast waves come in with their usual strength.' It has taken this length of time before all the electrons that have been knocked out of atoms by the sunspot bombardment have joined up with atoms again and the normal degree of ionization, due to the Sun's ordinary radiation, has been restored."

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ASTRONOMICAL ANECDOTES

CRICKETS AND PIPE-SMOKE SPECTRA

A FEW DAYS AGO, I was reminded of something when I ran across a letter to me from Professor E. B. Frost, who was director of the Yerkes Observatory from 1905 until 1932. In his later years he was blind, yet carried on some of his own correspondence, printing in capital letters on a narrow ribbon of paper. At the end, he signed himself, "E. B. Frost, IPSE." I knew him for only a little while but I shall never forget his telling me about Dolbear's formula.

In the middle of the night, when a cricket in the dome is your only companion, count the number of chirps in 15 seconds, add 40 to it, and the result will be the temperature, Fahrenheit. Usually an observer has plenty of time to count cricket chirps, so perhaps it would be best to count them for a minute, then divide by four before adding 40 to the result. This is Dolbear's formula. I know a cricket doesn't really chirp — he doesn't do it with his mouth, that is —but I don't know who Dolbear was or what he did. I've used his formula and it usually works.

Guiding a well-mounted large reflector that is collecting light for a spectrograph is sometimes a tedious job because the observer is not kept busy enough. The 37½-inch reflector in Ann Arbor guides very well at and near the zenith, the star trailing slowly along the slit and requiring a touch of the slow motion only every two or three minutes. The floor was pretty smooth, and they do say that one observer was accustomed to roller-skate around and around, among the piers and observing ladders, returning occasionally to see if the star was behaving itself. I forgot those skates when I left, darn it!

Another observer, lost in dreams of a greater instrument, sometimes lost the star as he puffed huge clouds of smoke from one of his pipes. This was Professor Heber D. Curtis, the director, who died about four years ago. Curtis' pipe was everywhere at once. He kept several of them, with cans of tobacco, scattered strategically about the observatory and the residence. If he left his pipe at the drawing board where he was designing the 96-inch reflector, he would find another one in his office. It could be laid aside when he went over to his home, for there would be another on the hall stand, and it soon would be in action. At the telescope, the clouds of smoke were so dense that some astronomers of the staff attributed any unfamiliar spectral feature to absorption through the equivalent of several atmospheres of tobacco smoke.

A considerable quantity of smoke arose recently from another cause, in Ann Arbor. The Students' Observatory of the University of Michigan, atop beautiful Angell Hall, has two domes, one housing a 10-inch refractor, the other a 15-inch reflector. In putting a new coating on the roof of the building, the workmen very carelessly tarred down one of the domes, so it could not be moved. The *Michigan Daily*, campus newspaper, claims that the department of astronomy got "stuck on itself," but a member of that faculty looks at this incident as an example of negligence that is on a par with the gradual encroachment on the observatory by dormitories, hospitals, and power plants that have well-nigh rendered its functions unprofitable. For over 20 years, there has been a promise that a new observatory building will be provided in a protected location. Maybe an incident as small as this will be the motivation for the fullfillment of that promise. R.K.M.

NEW BOOKS RECEIVED

ONE WORLD OR NONE, various authors, 1946, *McGraw-Hill*. 79 pages, paper bound. $1.00.

This book is subtitled, "A Report to the Public on the Full Meaning of the Atomic Bomb." Contributors include 15 men from scientific, political, and military fields. The foreword is by Niels Bohr; the introduction, by A. H. Compton.

GEOLOGY APPLIED TO SELENOLOGY, I, The Imbrium Plain Region of the Moon; II, The Features of the Moon, *J. E. Spurr*, 1945, *Science Press*. 112 and 318 pages. $5.00.

Volume I, incorporated into this book, is a complete reprint of an earlier work. Volume II extends the author's study to the entire moon, with discussion of various types and type areas which contribute to a general treatment of the subject.

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(See page 2)

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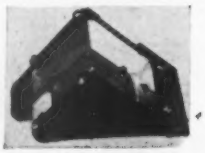

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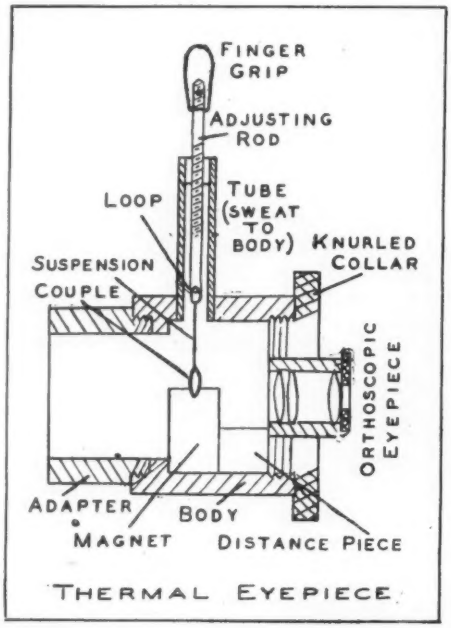
As is shown on the drawing, the instrument consists essentially of a minute, light couple suspended between the poles of a permanent magnet, one junction of the couple being at the focus of a positive eyepiece of orthoscopic or monocentric type. The whole is enclosed in a rather thick brass case which slips into the sliding eyepiece tube just as does an ordinary eyepiece. The device should be level, as the couple must be suspended freely. With an altazimuth mounting, the eye tube is always horizontal, but an equatorial mounting is preferable provided the tube or eye end rotates so as to bring the eyepiece level for any observing position. Adjustment is provided to enable the couple to be raised, lowered, or turned in the field of view.

The couple consists of strips of copper and constantan, with these dimensions: length 0.25", thickness 0.002", separation 0.005", weight 0.030 gram. The suspension is an exceedingly fine quartz thread, but a hair can be employed as its hygroscopic propensity can be neglected for short periods.



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lower junction of the thermocouple. If the image is too large, it may be necessary to shield the upper junction.

The thermoelectric current produced in the loop by the heat of the image causes the loop to turn in the field of the permanent magnet. Thus, if the loop is located edgewise before an observation, the amount of turning is observed as an apparent separation of the two wires. The thermal electromotive force of a copper-constantan junction is approximately 0.04 millivolts per degree centigrade. With a 12½-inch reflector, the radiation from the full moon when at a considerable altitude causes the strips to separate a distance equal to the apparent diameter of the crater Plato, approximately 53 seconds of arc when the moon is at its mean distance.

The relative intensity of radiation from different lunar regions can be ascertained by bringing various portions of the disk to the center of the field. After each observation the rays should be occulted and the couple again brought into coincidence. Care must be taken to avoid any shaking of the instrument as tremors are easily communicated to the couple.

In conducting these observations, the greatest care should be taken to shield the apparatus from every source of radiation which might distract from the accuracy of the results, and this includes the heat of the observer's body. Shielding is effected by the interposition of a non-conducting screen of asbestos or wood. Air currents are also detrimental, and the best results are obtained with the primary mirror mounted in a wooden tube used on still nights free from any suspicion of haze or fog. A thin layer of fog will completely absorb the very feeble heat rays which penetrate the earth's atmosphere. It has been estimated that the total amount of heat received from the full moon is only 750 millionths of a degree centigrade and may fall to ⅛ of this at sea level. At full moon the radiation is over five times that at first or last quarter.

Interesting observations can be secured during lunar eclipses. The turning moment of the couple will be found to diminish **before** the encroachment of the umbra and is reduced to zero during totality. A diminution of the heat from the moon is also noticed during penumbral eclipses (appulses), when our satellite escapes the dark shadow and the sun, as seen from the moon, appears partially eclipsed by the earth.

This compact little instrument is easily made, but attention must be paid to detail. The adjusting screw should turn readily without any lateral motion and should be provided with a bakelite finger grip. The couple must be suspended midway between the poles of the magnet. The magnet, of horseshoe shape, should be as strong as possible and accurately fit its recess. It is secured by the semicircular ebonite distance piece which in turn is gripped by the end of the knurled collar. This collar is bored to receive the eyepiece, which is a good push fit. The case is made of considerable thickness to eliminate extraneous heat as much as possible. Since the heat rays we are attempting to detect are readily absorbed by glass, as few surfaces as possible should be interposed between the primary and the thermocouple. A diagonal plane reflects a higher percentage than a right-angle prism transmits. If the telescope is temporarily converted to the Herschelian principle (off-axis), the maximum effect is produced. To avoid body-heat interference at the open end of the tube, it is advisable to employ a prism at the eyepiece.

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In Focus

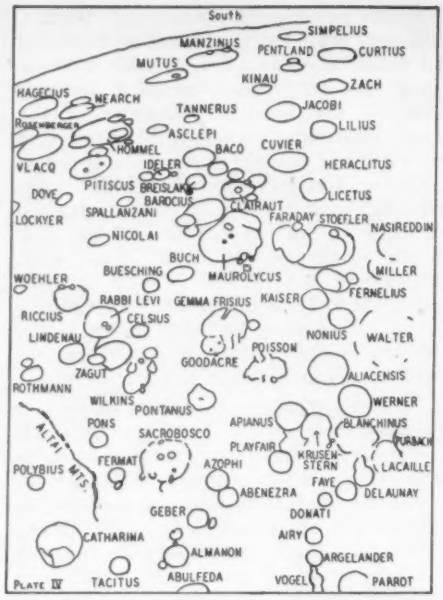
THIS MONTH'S back-cover picture adjoins the first one in the series, printed in the February issue, and continues around the southern limb of the moon. The terminator (sunrise line for first quarter) extends down the right side of the field of the photograph; the terminator's full length will be included in four charts.

There are 79 features labeled on the accompanying key chart, representing all of the named formations in this area. Because of this large number of features, only some of the more noteworthy are discussed below. In all cases, spellings follow the International Astronomical Union's **Named Lunar Formations,** by Blagg and Mueller. Bibliographical information is from the British Astronomical Association publication, **Who's Who in the Moon.**

Aliacensis. A crater over 50 miles in diameter, with walls which rise as much as 16,000 feet in places; note their long shadows.

Altai Mts. This mountain chain runs for over 300 miles, at heights of about 4,000 to 6,000 feet. The western slopes are very precipitous.

Apianus. A ring plain about 38 miles across, with a fairly smooth interior. It is named after Peter Bienewitz, a 16th-century mathematician who discovered that cometary tails always point away from the sun. His records of the 1531 comet were used by Halley in predicting the return of the comet which now bears Halley's name.



Barocius. A large formation not fully enclosed, with the crater Barocius B in its walls, and the less distinct C to the north. Named for a 16th-century Venetian nobleman.

Catharina. This formation was named for St. Catherine of Alexandria, by Riccioli, who placed Sts. Cyrillus and Theophilus nearby (see Plate I). Catharina is a ring plain over 60 miles across, with Catharina F the 25-mile plain in its northern side.

Faraday. A walled formation which seems to intrude into Stoefler. Michael Faraday (1791-1867) was the famous worker in physics, electricity, and magnetism.

Hommel. A bay over 75 miles in diameter, with several large craters inside its walls. Johann Hommel (1518-1562) was professor of mathematics at Leipzig University; under him Tycho studied astronomy.

Maurolycus. One of the finest walled plains on the moon, 70 miles in diameter. There is considerable detail in and around this feature; small craterlets and a central peak are particularly noticeable on its floor. On the eastern side, the walls rise 18,000 feet above the interior. The Franciscan abbot, Francesco Maurolico (1494-1575), was a noted mathematician and opponent of the Copernican system.

Pons. At this phase, the formation is ear-shaped. Jean Louis Pons (1761-1831) discovered 36 comets, starting his career as caretaker of Marseilles Observatory in 1789. He was a telescope maker; later director of the Museum Observatory in Florence, where he died.

Sacrobosco. A large irregular bay with great detail around it and several prominent craters in its interior. It commemorates John Holywood, universally known by his Latin name, who wrote a textbook on astronomy, **Sphaera Mundi,** based on the Ptolemaic system. This textbook, used for over 300 years, was later corrected by Barocius. Sacrobosco died in 1256.

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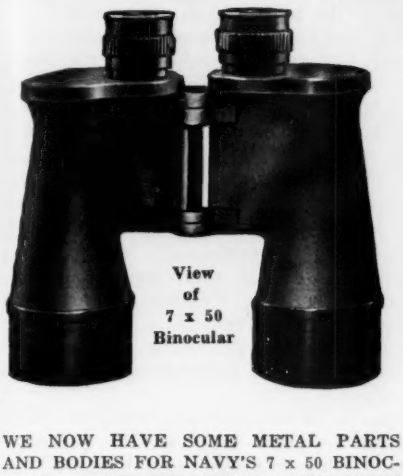

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OBSERVER'S PAGE

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A Beautiful Aurora and Colored Sunspots

MANY OBSERVERS of the aurora which overspread the northeastern United States on Saturday evening, March 23rd, likened its splendor to that of the display of September 18-19, 1941. Among those sending in reports is David W. Rosebrugh, Waterbury, Conn., who writes:

"On March 23, 1946, at 7:30 p.m. EST, an unusually beautiful aurora was seen from Waterbury. A great red arc 10 degrees in width stretched like a rainbow across the northern sky, arching from the northwestern horizon over Polaris to the northeastern horizon. The semicircle of sky below it was filled with a pale green diffuse aurora. By 8:30 most of the color had disappeared and the display consisted of roughly parallel arcs extending across the sky from east to west, although much broken up. The most southerly arc was far to the south, arching only 35 degrees above the southern horizon, while the most northerly arc passed about through the zenith. Pulsations commenced and a pulsating half-corona appeared, but not a complete corona, at least up to 9 p.m."

That afternoon, Mr. Rosebrugh had observed the sun with his 6.2-inch Gray refractor, using a 2-inch Mogey Huygenian eyepiece of 46x, a Mogey dark glass and a Mellish solar prism, all of excellent quality. There was a large sunspot in the northeast quadrant of the sun; this spot was the preceding member of a large group of some 20 spots. The penumbra was as usual a dark gray, but its following side showed a brilliant rusty color which gradually waxed and waned several times. During one of the waning periods, the color turned to purple and then lilac and finally to the normal dark gray. Eventually, the penumbra settled down to the usual shade all around.

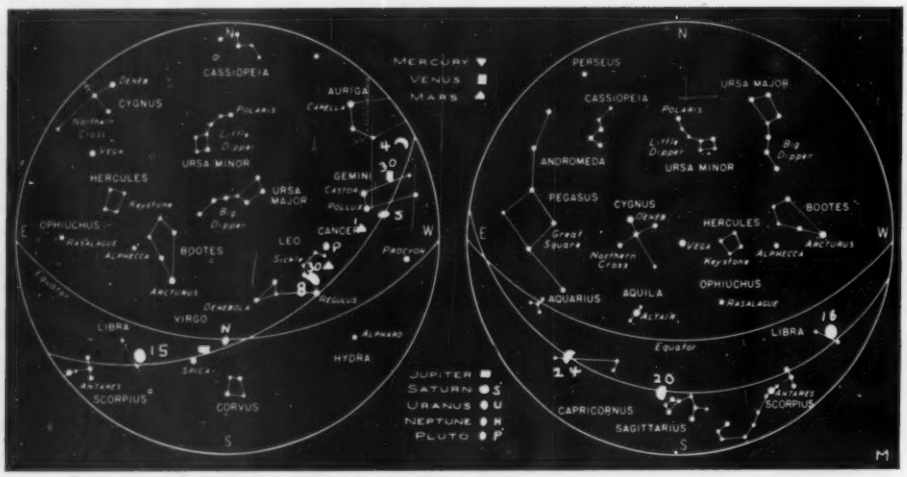
The next day Mr. Rosebrugh found that a small umbra had developed at the outer edge of the penumbra at the point where the unusual colors were seen the day before, but somewhat similar colored effects were seen by both him and his wife on the preceding portion of the penumbra.

Earlier this year, similar unusual purple and violet colors had been observed, and Mr. Rosebrugh calls attention to reports of similar phenomena on page 31 of Volume 1, **Celestial Objects for Common Telescopes,** fifth edition, by the Reverend T. W. Webb, and on page 77 of **Problems in Astrophysics,** by Agnes M. Clerke.

Also from Connecticut, Eliza M. Chatfield, of Seymour, reports, "The aurora on March 23rd was the most beautiful and unusual one I have ever seen. The west had a great band of color pulsating from pale pink to deep crimson and out from it came delicate streamers of white."

At Rochester, a clear sky gave a fine view of the aurora. Paul W. Stevens writes that at 8:30 p.m. the lights were visible in all parts of the sky and were brightest south of the zenith, even into Canis Major. There were long streaks and brilliant patches of green, while in the east and west were beautiful contrasting curtains of red. By 4:30 a.m., the pulsating type of aurora was most pronounced, and the colors seemed to flicker

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 3:30 a.m. local time on the 7th of the month, and at 2:30 a.m. on the 23rd. At the left is the sky for 9:30 p.m. on the 7th and 8:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury is not favorably placed for observation. With difficulty it may be seen during the first few days of the month shortly before sunrise. On the 31st, it will be in superior conjunction with the sun, moving into the evening sky.

Venus, an easy object in the early evening sky, can be followed for two or more hours after sunset. On May 1st, it will be between the Pleiades and the Hyades; on the 23rd, it will cross the boundary into Gemini; by the 31st it will be close to Epsilon Geminorum.

Mars continues to grow dim as the sun approaches it in the evening sky. An interesting series of conjunctions occurs on the 7th, when Mars passes northward of the Beehive, M44, in Cancer, although the moon is near at the time. Watch the planet for a day before and after, too, and its motion can be easily detected in field glasses. By the end of the month, Mars enters Leo.

Jupiter can be seen most of the night in western Virgo, of —1.9 magnitude. It continues to move westward among the stars. By the end of May it is close to the 4th-magnitude star, Theta Virginis.

Saturn remains south of Castor and Pollux, in Gemini, and sets four hours after the sun. Its brightness has decreased to +0.4.

Uranus cannot be seen, as it is only a short distance from the sun in the evening sky.

Neptune is visible in field glasses most of the night near Gamma Virginis. It is of the 8th magnitude, and its position on the 15th is $12^h\ 24^m.9$, —1° 3′ (1946).

For latitudes near 40° north, in the first few days of May there will be 15 1st-magnitude objects above the horizon one hour after sunset: Venus, Jupiter, Sirius, Vega, Capella, Arcturus, Rigel, Saturn, Procyon, Betelgeuse, Aldebaran, Mars, Spica, Pollux, and Regulus. Most of these will be in the western sky — Rigel will be quite low and nearly set, but Vega will be rising in the northeast.

EDWARD ORAVEC

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**

Configurations at 5h 0m for an Inverting Telescope

May	West	East
1	·2 ·1 ○	
2	○	
3	·1 ○ 2· 3·	·4
4	○3· 2· 1○·	·4
5	3· ·2 ○	4· ·1●
6	·3 1· ○ ·2	4·
7	○2· ·3 ○ ·1	4·
8	·21· ○	
9	4· ○ ·21· ·3	
10	4· ·1 ○ 2· 3·	
11	4· 2· ○	
12	4· 3· ·2 ○	·1●
13	·4 ·3 1· ○ ·2	
14	·4 ·3 2○· ·1	
15	·4 ·21· ○ ·3	
16	·4 ○ ·21· ·3	
17	·1 ○ 2· 3·	
18	2· ○ ·4	
19	3· ·2 ·○1 ·4	
20	○1· 3· ○ ·2	·4
21	·3 ○	·4
22	2· 1· ○	4· ·3●
23	○ ·1 ·3 4·	·2●
24	·1 ○ 2· 4·3·	
25	2· 4○·	
26	·1○	
27	○1· ○ ·2	
28	4· ·3 ○ 2·	·1●
29	4· 2· 1· ○	·3●
30	·4 ·○2 ·1 ·3	
31	·4 1· ○ 2· 3·	

as does a dying campfire. During the morning of March 24th, Mr. Stevens observed a large sunspot without telescopic aid.

From Philadelphia, Aaron Liss sent a drawing of the numerous sunspots, and he also reported the brilliant auroral display. Another Pennsylvania amateur, Theodore R. Sprecher, of Ephrata, was impressed especially by the intensity of the auroral colors and the extension to the south of the zenith. He says:

"Due west there was a marked pillar of red light. This was really red — not pink or rose. This area waxed and waned in intensity but did not change position for about a half-hour . . . . From about 8:45 to 9:30 p.m. the display really went to town! The west point was a mass of broad, colored rays with red predominating . . . . At about 10:30 there was an intense 'spotlight' ray due east, instantly going out and then reappearing a degree or so on either side . . . . My last observation was made at midnight, when the display was still going strong."

METEOR SHOWERS

The Gamma Aquarid meteor shower will be at maximum from May 4th to 6th, with total duration of the shower from the 2nd to 8th. The shower can best be seen a few hours before sunrise as the radiant does not rise till quite late. Very swift meteors are typical, with long paths. The moon will not interfere with observation, as it is just past new.

Two other minor showers may be visible in May. The Zeta Herculids are scheduled from the 11th to 24th; swift meteors are typical. The Eta Pegasids, slow meteors, occur on the night of May 30-31.

Rates for all these showers will be low. With a clear sky perhaps six or seven can be expected per hour.

E. O.

VARIABLE STAR MAXIMA IN MAY

These predictions of variable star maxima are made by Leon Campbell, recorder of the A.A.V.S.O., Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. The data include, in order, the day of the month near which maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

May 4, R Hydrae, 4.6, 132422; 4, Chi Cygni, 5.3, 194632; 4, T Centauri, 6.1, 133633; 10, R Cancri, 6.8, 081112; 13, R Phoenicis, 7.8, 235150; 20, S Carinae, 5.7, 100661; 21, U Cygni, 7.6, 201647; 23, R Leporis, 6.7, 045514; 29, R Virginis, 6.9, 123307.

MINIMA OF ALGOL

May 3, 19:25; 6, 16:14; 9, 13:03; 12, 9:52; 15, 6:41; 18, 3:29; 21, 0:18; 23, 21:07; 26, 17:56; 29, 14:45.

OCCULTATION PREDICTIONS FOR MAY

4-5 **8 Geminorum** 6.1, 6:13.0 +23-59.4, 3, +73° +7° Im: **B** 1:59.9 —0.3 —0.7 64°; **D** 1:59.3 —0.4 —0.9 76°; **E** 1:58.6 —0.5 —1.4 99°; **F** 2:15.8 +0.1 —2.9 141°.

4-5 **9 Geminorum** 6.3, 6:13.7 +23-45.7, 3, +90° +20° Im: **B** 2:14.4 +0.2 —1.6 112°; **D** 2:18.7 +0.2 —1.9 123°; **E** 2:32.0 +0.7 —3.6 155°.

12-13 **65 Virginis** 5.9, 13:20.5 —4-38.5, 11, +86° +28° Im: **A** 6:00.2 —0.6 —2.7 163°; **B** 5:51.6 —0.7 —2.5 160°; **C** 6:08.4 —0.3 —3.4 177°; **D** 5:52.7 —0.5 —2.8 170°.

13-14 **95 Virginis** 5.5, 14:03.9 —9-03.4, 12, +81° 0° Im: **A** 4:30.2 —2.2 —0.7 93°; **B** 4:25.5 —2.2 —0.5 90°; **C** 4:22.5 —2.2 —0.9 108°; **D** 4:14.3 —2.1 —0.5 102°; **E** 3:55.2 —1.6 —0.8 128°; **F** 4:03.4 —0.4 —2.8 170°.

13-14 **Kappa Virginis** 4.3, 14:10.0 —10-01.4, 12, +80° +22° Im: **F** 9:16.9 —0.9 —3.1 161°; **G** 8:11.8 —1.1 —1.6 137°; **H** 8:37.0 —0.9 —3.0 168°; **I** 8:04.1 —1.1 —1.6 148°.

16-17 **Omega Ophiuchi** 4.6, 16:28.9 —21-21.2, 15, +69° +1° Im: **A** 7:58.5 —1.7 —0.2 55°; **C** 7:50.0 —2.2 —0.1 63°; **E** 7:15.2 —2.7 +0.4 72°; **F** 6:54.5 —2.6 —0.2 102°; **H** 6:13.2 —1.1 —0.1 124°. Em: **A** 8:54.3 —1.6 —2.7 330°; **C** 8:56.1 —1.8 —2.6 324°; **D** 8:39.7 —1.7 —2.6 335°; **E** 8:28.3 —1.8 —2.1 326°; **F** 8:31.7 —2.4 —1.5 302°; **G** 7:41.8 —1.1 —0.5 322°; **H** 7:36.9 —2.0 0.0 288°; **I** 7:32.1 —1.1 0.0 309°.

17-18 **b Ophiuchi** 4.3, 17:23.1 —24-07.6, 16, +66° +18° Im: **E** 9:47.5 —2.0 —1.4 113°; **F** 9:48.3 —2.5 —2.1 132°; **G** 8:56.4 —1.6 0.0 105°; **H** 8:50.2 —1.7 —0.8 133°; **I** 8:42.3 —1.4 +0.3 114°. Em: **E** 11:06.6 —1.1 —0.9 256°; **F** 11:02.6 —1.4 +0.1 239°; **G** 10:21.2 —1.7 —0.7 278°; **H** 10:14.3 —2.7 +0.1 257°; **I** 10:06.0 —1.8 —0.2 274°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
	I +123°.1 +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

SOLAR ECLIPSE

There will be a partial eclipse of the sun on May 30th, visible only in the South Pacific. At maximum the sun will be 89 per cent obscured.

PHASES OF THE MOON

New moon	May 1,	13:16
First quarter	May 8,	5:13
Full moon	May 16,	2:52
Last quarter	May 24,	4:02

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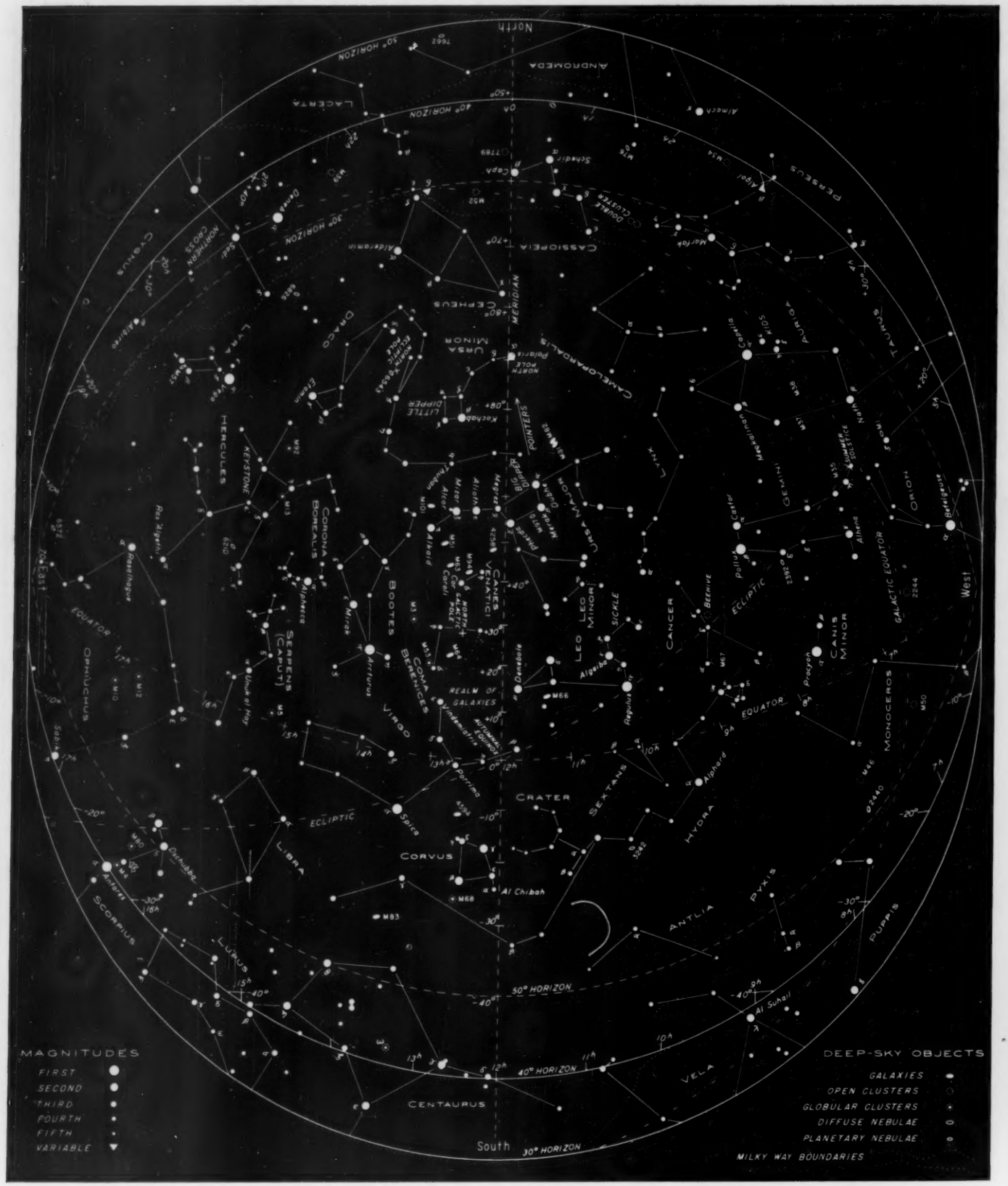


DEEP-SKY WONDERS

A NEST of galaxies lies across the meridian in May. This super-marvel, the Coma-Virgo cluster, can be found on both sides of the boundary between the constellations from which its name is derived. It is seven million light-years distant, the galactic cluster nearest to our own. Of its 300 members about 30 can be seen in one evening by an amateur with a telescope of 12 inches or more.

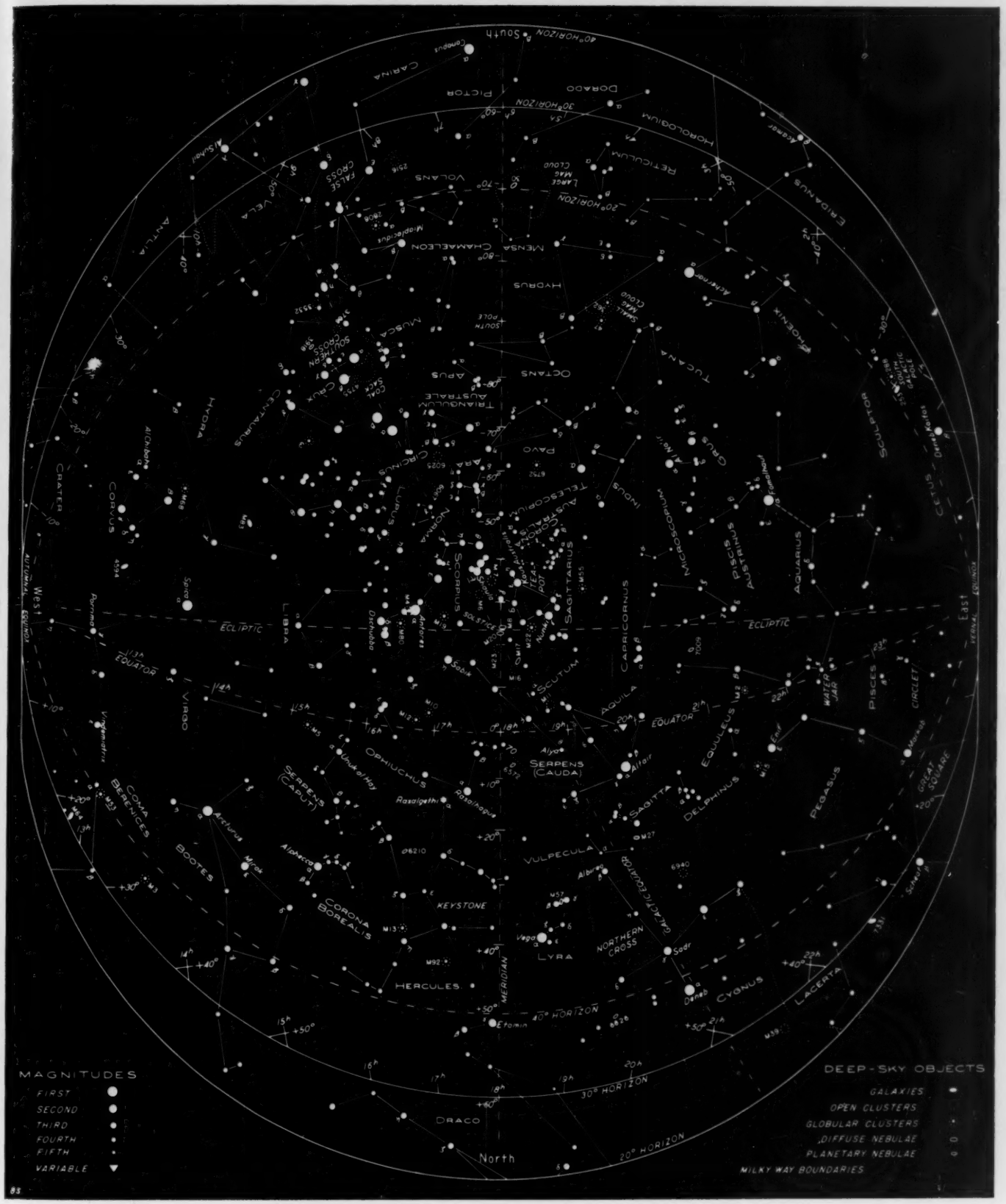
Look between Vindemiatrix and Denebola. In Virgo, preceding Vindemiatrix, are two ellipticals, M59, 12h 39m.5, +11° 55′, and M60, 12h 41m.1, +11° 49′, and a beautiful edge-on spiral, NGC 4762, 12h 50m.4, +11° 31′. M60 has a smaller spiral twin, NGC 4647. In Coma Berenices, following Denebola, are three spirals, M98, 12h 11m.3, +15° 11′; M99, 12h 16m.3, +14° 42′; M100, 12h 20m.4, +16° 6′.

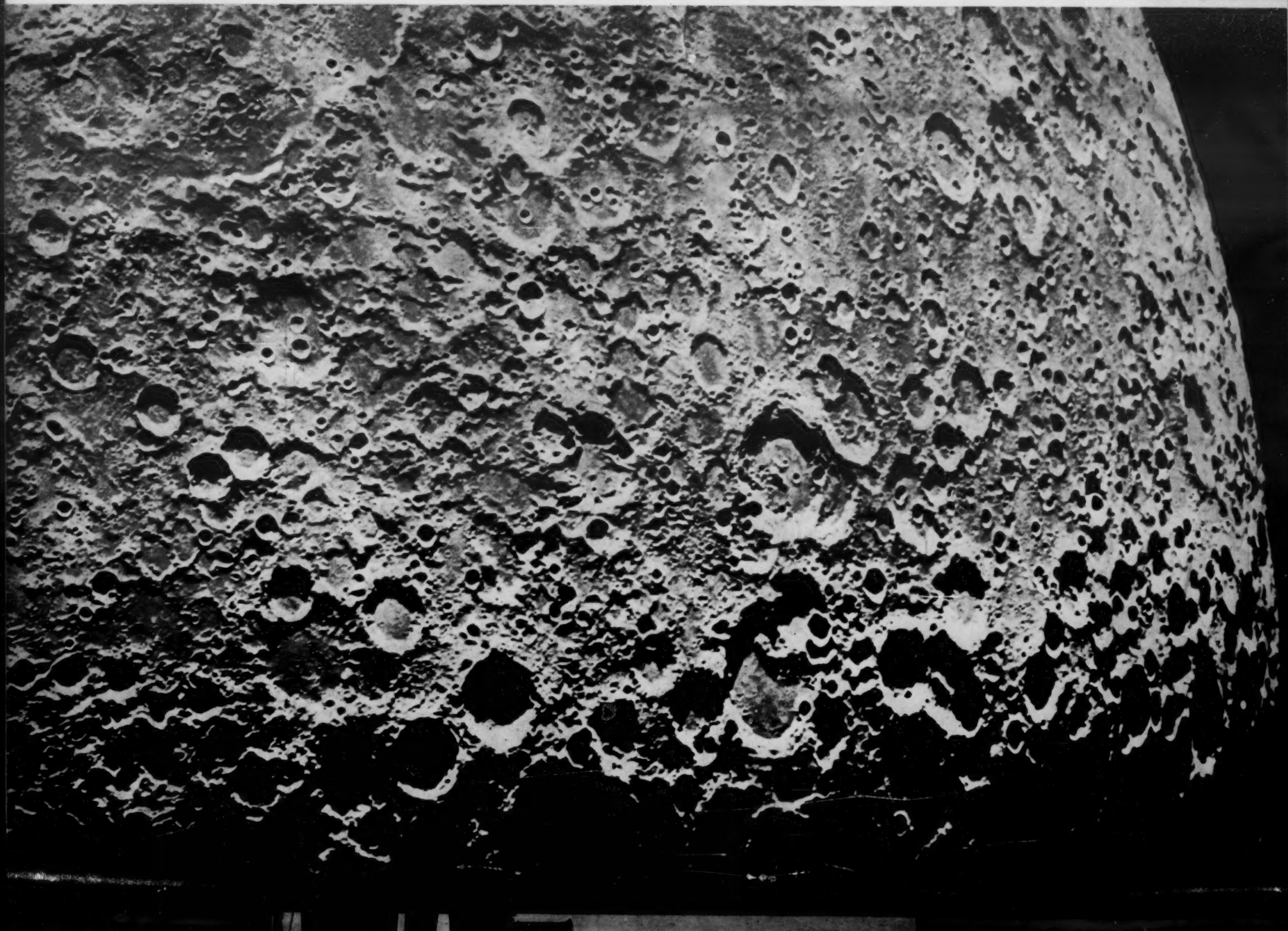
Remarkable, but difficult, are the very faint Siamese twins in Virgo, NGC 4567-68, 12h 34m, +11° 32′.

L. S. COPELAND

STARS FOR MAY

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.



EVENING STARS FOR SOUTHERN OBSERVERS

THIS CHART is prepared for a basic latitude of 30° south, but it may be used conveniently by observers 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. The sky is here shown as it appears on July 7th at 11 p.m., July 23rd at 10 p.m., August 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly, four minutes earlier per day. These are local mean times which must be corrected for standard time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts. For other charts in this series, see issues of alternate months, August, 1944, to June, 1945, and July, 1945, to the present.